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Lithostratigraphy of the Cedar Keys Formation of Paleocene and Upper Cretaceous Age - Peninsular Florida and Environs

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TABLE OF CONTENTS

FIGURES

ABSTRACT

The Cedar Keys occurs throughout the Florida Peninsula and environs within the confines of the Rebecca Shoal barrier reef. The Cedar Keys is subdivided by lithologic character and corresponding geophysical log characteristics into six units.

In decending order they are: Unit A, characterized by a preponderance of anhedral and cryptocrystalline dolomite; euhedral dolomite is subordinate. Unit B is characterized by the presence of numerous relic grain textures in chalky to microcrystalline euhedral dolomite. Unit C is predominately anhydrite, with subordinate chalky to very fine microcrystalline euhedral dolomite. Unit D is characterized by a predominance of relic grains in a chalky to very fine microcrystalline euhedral dolomite, with few thin bedded anhydrites. Units E & F are similar in texture to Unit D, but contain fewer beds of relic grain texture. They are differentiated from each other only by E-log correlation.

The presence of Borelis gunteri establishes that at least Unit B and upper Unit C are Paleocene in age. Regional correlation shows that Units E and F are equivalent to, and a facies of, the Upper Cretaceous Pine Key Formation.

The Cedar Keys carbonate fraction is all dolomite; it and probably the associated anhydrites are secondary replacement of limestone. The secondary nature of the dolomite is demonstrated by the presence of numerous beds containing relic grain texture throughout the formation.

Subsidence of the South Florida Basin and Southeast Georgia Embayment continued throughout Cedar Keys deposition. The Peninsular Arch does not appear on the isopach of the A-D interval; this interval is not involved with facies changes into the Pine Key Formation.

The Plantation Tongue of the Rebecca Shoal barrier reef partially encircled the Peninsula in the late Upper Cretaceous and was responsible for the deposition of Units E and F. In the Paleocene, the Tavernier Tongue completely encircled the Peninsula and was responsible for the dolomite-anhydrite deposition of Units A through D.

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INTRODUCTION

Since the last regional study of the Cedar Keys by Chen in 1965, many new wells have been drilled. Sufficient lithologic data are now available to subdivide the Cedar Keys Formation into six units. With knowledge of the development of the Rebecca Shoal barrier reef, the presence of Units E and F within the South Florida Basin in the Upper Cretaceous is accounted for.

All lithologic data were acquired by myself from drill cuttings using a 10X stereoscopic microscope.

On Figures 17 & 18 the amount of sample data recovered from each lithologic control well is shown by symbol. Due to the almost universal loss of circulation in the overlying Black Point Format (see Appendix 3) rocks, few oil test wells have samples in the upper several hundred feet of the Cedar Keys.

In the northern 60 miles of the Florida Peninsula, regionally persistent anhydrites used to subdivide the Cedar Keys are not present.

In the text, Florida wells are designated by Permit Number followed by a three-letter county abbreviation (178CHA is Permit 178 in Charlotte County). Well numbers are shown on Figures 17 & 18. When no permit number was assigned to a well by the state, a capital letter is used; injection wells are designated by a lower-case letter and the triangle symbol. Offshore OCS wells are designated by their OCS number; Georgia wells are designated by the Georgia Geological Survey number.

Wells shown on the page-size maps are sample control only.

Estimating anhydrite thicknesses in older wells is less accurate than in newer wells, due to the poor definition of thin beds on the old resistivity curves, and the lack of a gamma ray curve.

Geographic subdivisions of the Florida Peninsula as used in the text are shown on Figure 1.

Definitions of dolomite textural types and other less generally known terms are presented in Appendix 1.

Numbered wells in the South Florida Basin which lack isopach or structure data (Figs. 17 & 18) were used to construct the maps of unit and anhydrite thicknesses of Units C through F.

PREVIOUS INVESTIGATIONS

Cole in 1944 described and named the Cedar Keys Formation, but assigned neither a type well nor type depths.

Applin and Applin in 1944 contributed additional data on the formation and presented a geologic column of the No. 2 Scholtz well, which was also known at the time as the "Cedar Keys" well. They also did not designate a type well.

Chen in 1965 more fully described the Cedar Keys and presented cross-sections and lithofacies maps. His descriptions of the formation are in today's lithologic composition terms. He did not assign a type well.

Winston in 1977 finally designated Cedar Keys Formation type and co-type wells with type depths. The type well was designated the No. 2 Scholtz "Cedar Keys" well and the co-type was designated the nearby Coastal 1 Ragland well.

Winston (1994) ascribed the dolomite-anhydrite composition of the Cedar Keys to lagoonal deposition behind the Rebecca Shoal barrier reef.

STRATIGRAPHY

OCCURRENCE

The Cedar Keys Formation occurs within the confines of the Rebecca Shoal barrier reef of which it is the lagoonal facies. It is present throughout the Florida Peninsula, southeastern Georgia and in the offshore South Florida Basin (Fig. 18).

LITHOLOGY

General

The upper 100-300 feet of the Cedar Keys (including Unit A and upper Unit B) is frequently missing in oil tests. In wells drilled since 1960 in central and south Florida, samples are rarely caught above Unit C, into which casing is set, nor are geophysical logs run above this casing point.

The carbonate fraction of the Cedar Keys is entirely dolomite. The lower Cedar Keys and upper Pine Key are involved in an interfingering transition zone, limestone or chalk of the Pine Key is therefore occasionally present in the basal Cedar Keys. Stringers of Cedar Keys dolomite lithology are frequently present in the upper Pine Key chalk or limestone.

The base of the lowermost thick dolomite bed is designated the base of the Cedar Keys in this study.

The definitive characteristic of Unit A is a predominance of anhedral and cryptocrystalline dolomite; euhedral dolomite is subordinate. Unit B is characterized by the presence of numerous relic grain textures in chalky to microcrystalline euhedral dolomite. Unit C is predominately anhydrite, with subordinate

chalky to very fine microcrystalline euhedral dolomite. Unit D is characterized by a predominance of relic skeletal, oolite, and pellet grains in a chalky to very fine microcrystalline euhedral dolomite, with few if any thin bedded anhydrites. Units E and F are similar in texture to Unit D, but contain fewer beds of relic grain texture. They are differentiated only by E-log correlation.

Units C, D and E were established on regionally persistent anhydrites (see cross-sections). As Unit F was not present in the South Florida Basin reference well, the type well for Unit F is designated as P 167. This well has the thickest Unit F interval of available lithologic data. Correlation of local Pine Key kicks on the E-log establishes that Unit F in Well 167 (see cross-section E-F) is equivalent to the upper Pine Key in Well 121. Regional correlations of the anhydrites above Unit F in Well 167 and others in the vicinity establish that Units C and B have thinned considerably in the southeastern Peninsula.

Unit F (Fig. 3) (4990-5395 in P 167)

Unit F is present only in the South Florida Basin. The thickness of Unit F is very irregular due to interfingering with the limestone and chalk of the Pine Key Formation.

Euhedral dolomite dominates the unit; anhedral dolomite is present and is more common than in the overlying units. Euhedral crystal sizes vary from fine microcrystalline to medium crystalline. On the whole, crystal size is usually coarser in Unit F than in younger units. Relic grain textures are also fewer. When present, they consist of very fine to fine skeletal grains, and very fine pellet grains.

Colors are cream, tan, brown and gray.

Intercrystalline, pinpoint and vug porosity is generally good. Intercrystalline porosity up to 20% is common in euhedral dolomite.

Anhydrite in any form is rare.

Unit E (Fig. 4) (4855-5325 in P 679)

Thicknesses are highly variable north of the area where Unit F is present. With the absence of Unit F, the interfingering of Cedar Keys and Pine Key lithologies now occupies the lower section of Unit E, and thus accounts for the irregular thicknesses.

This unit is predominantly euhedral dolomite; in the North and South-Central Florida areas occasional beds of anhedral and cryptocrystalline dolomite are present. Euhedral dolomite is very fine microcrystalline to very fine crystalline. Relic grain texture is less prevalent than in the overlying Unit D. Skeletal grains are very fine to fine grain in the North and South-Central areas; in the South Florida Basin some medium skeletal grains are present.

Colors are tan and cream with brown present in the North and South-Central areas.

Intercrystalline and pinpoint porosity ranges from 5% to 15%.

In the North and South-Central areas, anhydrite consists of nodules and selenite porosity-plugging. A few beds of anhydrite are present in the South-Central and the South Florida Basin areas.

Unit D (Fig. 6) (4555-4855 in P 679)

Euhedral dolomite with relic grains is the predominant lithology; anhedral dolomite is rare. Very fine to medium skeletal grains dominate this unit with fine to medium grain oolites and very fine grain pellets occasionally present.

In the South Florida Basin, the euhedral dolomite is principally very fine microcrystalline; chalky dolomite predominates in the North and South-Central areas.

Colors are cream, tan and gray in the North and South-Central areas; in the South Florida Basin, colors are the same except that gray is rare.

Porosity values range from 5% to 20% in intergranular, pinpoint and intercrystalline porosity in the North and South-Central area and in the South Florida Basin. In the southern South Florida Basin, chalky porosity predominates with 5% to 10% intercrystalline and moldic porosity present in limited quantities.

In the South-Central area and South Florida Basin, anhydrite beds are relatively thin. In the North-Central area anhydrite beds are absemt--only nodular anhydrite is present.

Unit C (Fig. 8) (3630-4555 in P 679)

This unit is mostly anhydrite in numerous thick beds. The intervening dolomite is euhedral, chalky to very fine microcrystalline in all areas, with occasional very fine to fine relic skeletal grains. Very fine pellet grains are common in the South Florida Basin. Fine to medium grain oolites are occasionally present in all areas.

Dolomite colors are cream, gray and tan.

Porosity, when present, is generally chalky with occasional zones of 5% to 10% intergranular, moldic and pinpoint porosity, particularly in the North and South-Central areas. In the South Florida Basin porosity is almost exclusively chalky.

Up to 26 beds of anhydrite can be identified on modern geophysical logs in Unit C, varying from a few feet to 50 feet in thickness.

Unit B (Fig. 8) (3040-3630 in P 679)

Euhedral dolomite is predominately chalky to microcrystalline with common relic skeletal texture. Occasional pellet and oolite grains are present in the North-Central area, becoming more common in the South-Central and South Florida Basin areas. Grain size is very fine to fine.

Colors are gray, tan and cream.

Porosity is usually 5% moldic and intergranular. Granular and intercrystalline porosity from 10% to 20% is common in the South-Central and South Florida Basin areas, but is only occasionally present in the North-Central area.

In the North-Central area, thin anhydrite beds are occasionally present, as is selenite porosity plugging. Numerous anhydrite beds, nodules and selenite plugging are present in the South-Central and South Florida Basin areas. In Highland and Glades Counties anhydrite beds total over 200 feet.

Unit A (Fig. 11) (2875-3040 in P 679)

Anhedral, cryptocrystalline, and occasional euhedral dolomites characterize this unit. Cryptocrystalline dolomite is frequently lithographic with conchoidal fracture. Occasional euhedral dolomites are chalky to microcrystalline in the North

and South-Central areas, with fine to medium crystalline texture appearing in the South Florida Basin. In the injection wells along the coast and near the Rebecca Shoal reef, euhedral texture is common. Rare relic very fine to fine skeletal grains are present in the South-Central and South Florida Basin areas.

Colors include gray, tan, cream, brown, and occasionally dark gray. Gray colors are more prevalent in the North and South-Central areas; in injection wells along the southeastern coast the signature gray color at the top of the unit is occasionally absent, and the top of the Cedar Keys must be picked on geophysical logs.

Porosity in the North-Central area varies from chalky to 10% intercrystalline and pinpoint. In the South-Central area 5% pinpoint, vug and intergranular porosity is common. When euhedral dolomite is present, it can contain up to 15% intercrystalline porosity. In the South Florida Basin, up to 10% intercrystalline porosity is common when euhedral dolomite occurs.

Occasional cavities several feet in height are present in injection wells along the southeastern coast. In these wells and in Well 232MON, intercrystalline porosity up to 20% was observed.

In Unit A, bedded anhydrite is confined to the northern South Florida Basin area (Fig. 11). Neither nodules nor selenite porosity plugging were seen anywhere.

Unit A is similar in its textures to the overlying Delray Dolomite (Appendix 5). Together they comprise the "Boulder Zone" of the southeastern Peninsula.

Cedar Keys Undivided (Figs. 18 & 12)

In the northern Peninsula, subdividing the Cedar Keys into

units is not possible, as the defining anhydrite beds are not present. The undivided Cedar Keys consists of Units A through D with a thin section of Unit E.

Here dolomite is predominantly euhedral. Crystal size is mostly chalky to microcrystalline, occasionally fine crystalline, and rarely medium crystalline. Relic-grain texture is common in chalky to fine microcrystalline dolomite. Fine to medium skeletal grains are present throughout the area and are abundant. Medium to coarse grain oolites occur only in local areas. Very fine grain pellets are rare.

The occurrence of anhedral dolomite is widespread but the percentage is low. Cryptocrystalline dolomite is rare.

Tan, cream and gray are the common colors; variations of brown are rare.

Porosity in euhedral dolomite is common, usually some 5%. Maximum visually estimated porosity was 15%, occurring in fine to medium crystalline euhedral dolomite. Microcrystalline dolomite contains porosity ranging from 5% to 10%. Vug porosity is rare. In the relic grain texture, intergranular porosity up to 15% is frequently present. Moldic porosity is rare.

A thin, gray flaky bentonite (Fig. 10) was observed in the drill cuttings of Well 77CLB. This was the only occurrence I encountered in cuttings; bentonite is usually washed away due to its tendency to disintegrate when wet. The bentonite bed usually occurs some 250 feet below the top of the Cedar Keys and is characterized on E-logs by a distinctive SP deflection.

A few beds of anhydrite are present (Fig. 12); anhydrite nodules and selenite pore-filling are common. In southeastern Georgia ten beds of anhydrite totaling 85 feet were encountered

in Well GGS 3537. This thicker bedded anhydrite is in a local basin (see Fig. 18).

AGE

Borelis gunteri and B. floridana (Fig. 9) occur mostly in Unit B but are occasionally present in the uppermost section of Unit C. These indicate a Paleocene age (Cole 1944).

Units C & D have no reported fossils, but I have observed an occasional unidentified foraminifer.

At least the upper part of Unit E is correlative with the Upper Lawson Formation in its co-type locality (Well 101MAR). Fossil data reported by Applin & Applin (1944 & 1967) indicate an Upper Cretaceous Navarro age for the Upper Lawson.

As Unit F underlies Unit E, it must also be of Upper Cretaceous age.

Unit A, above the established Paleocene Unit B and below the established Eocene of the middle Black Point Format limestone, could be of either age, but is most likely Paleocene.

Units A through D appear to be essentially Paleocene in age.

ORIGIN

Relic skeletal, oolite and pellet grains are common in the dolomites of the Cedar Keys. These relic grains indicate that the dolomite is a secondary replacement of limestone. This replacement was probably induced by a rise in salinity caused by a restriction of marine circulation by the presence of the Rebecca Shoal barrier reef. The rise in salinity probably stimulated the activity of Folk's nannobacteria.

In his 1993 abstract he says:

> "... in some situations the nannobacteria catalyzed precipitation of dolomite and their bodies were incorporated into the mineral. The negatively-charged bacterial cell wall attracts Ca and Mg ions, thus must increase the solubility product and leads to super saturation on a 0.1 um scale. In this way the kinetic barrier to dolomitization is side-stepped; the presumption is that where Mg-concentrating bacteria are abundant, dolomite will form, and where they are absent, precipitation is either much slower or may not occur at all."

Anhydrite in the Cedar Keys is probably also a replacement of selected limestone beds. Constraints on the deposition of anhydrite by evaporation of sea water without a trace of halite, are almost as great as for a chemical deposition of dolomite. In the Cedar Keys, no signs of halite were seen in this study, nor have any been reported.

STRUCTURE

Figure 15 shows the regional structure of the Florida Peninsula and environs.

The structure map (Fig. 17) on the Cedar Keys top shows the Peninsular Arch, Southeast Georgia Embayment, and the South Florida Basin.

The Peninsular Arch, however, is not shown on the isopach map of the Cedar Keys (Fig. 18) although both the Southeast Georgia Embayment and the South Florida Basin are shown. The irregular thicknesses due to interfingering and change of facies between the lower Units (E & F) of the Cedar Keys and the Pine Key give a distorted picture of structural conditions during Cedar Keys deposition period.

To overcome this distortion, an isopach of Units A through D was constructed (Fig. 16). None of these units interfinger with the Pine Key; therefore, this map presents a more accurate picture of Cedar Keys structural activity.

The A-D isopach shows a normal thickening into the South Florida Basin and the Southeast Georgia Embayment. In the North and South-Central areas, the isopach lines show a slight thickening across the Peninsular Arch, showing that subsidence on the flanks of this feature did not occur during the Paleocene.

The presence of the Peninsular Arch on the Cedar Keys structure map indicates that subsidence on the flanks was again active after the Paleocene.

GEOLOGIC HISTORY

In the Late Cretaceous the Plantation Tongue (Figs. 2 & 14) of the Rebecca Shoal barrier reef (Winston, 1994) had encircled the south half of the Peninsula. This condition apparently caused a rise in the salinity in the central part of the South Florida Basin area, bringing about the deposition of the dolomites and occasional thin beds or nodules of anhydrite in Units F and E. In the northern Peninsula chalky limestone was deposited at this time.

When the Tavernier Tongue (Figs. 6 & 14) completely surrounded the Peninsula, the restricted marine circulation resulted in the deposition of the dolomite and anhydrite of Unit D, and the predominantly anhydrite Unit C throughout the central and southern Peninsula.

In Units B and A anhydrite deposition decreased through time in favor of dolomite, except in the South Florida Basin.

The structural platform of the Cedar Keys-Rebecca Shoal reef form the basis for deposition of the Eocene-Oligocene Black Point Suites (Fig. 13), characteristic of the Florida Peninsula.

BIBLIOGRAPHY

Applin, P.L. & Applin, E.R., 1944, "Regional subsurface stratigraphy and structure of Florida and southern Georgia", Bull AAPG, v. 28, p. 1673-1739.

Applin, P.L. & Applin, E.R., 1967, "The Gulf Series in the subsurface in northern Florida and southern Georgia", US Geol Sur Prof Paper 324 G, 34 p.

Chen, C.S., 1965, "Regional lithostratigraphic analysis of Paleocene and Eocene rocks of Florida", FL Geol Sur Bull 45, 105 p.

Cole, W.S., 1944, "Stratigraphic and paleontologic studies of wells in Florida (no. 3), FL Geol Sur Bull 26, 168 p.

Folk, R.L., 1993, "Dolomite and dwarf bacteria (nannobacteria)", Geol Soc Amer Abstracts with Programs, Vol 25, No. 6, p. A-397.

Vernon, R.W., 1951, "Geology of Citrus and Levy Counties, Florida", FL Geol Sur Bull 33, 256 p.

Winston, G.O., 1977, "Co-type wells for the five classic formations in Peninsular Florida", GCAGS, p. 421-27.

Winston, G.O., 1993, "The Paleogene of Florida - Vol. 2 - A regional analysis of the Oligocene-Eocene section of the Peninsula using vertical lithologic stacks", Miami Geol Soc, 53 p.

Winston, G.O., 1994, "The Rebecca Shoal dolomite barrier reef of Upper Cretaceous and Paleocene age - Peninsular Florida and Environs", Miami Geol Soc, 47 p.

WELL LIST

Permit	Operator	Lease	
1	Ohio	1	Hernasco
4	Sun	1	Crapps
5	Sun	1	Adams
8	Humble	1	Carroll
11	Stanolind	1	Forest
12	Gulf	1	Model
13	Sun	1	Goethe
16	Gulf	1	State (374)
19	Sun	1	Powell
22	Gulf	1	Big Pine Key
29	Humble	1	Jameson
31	Humble	1	Hayman
36	Sun	1	Langston
41	Tidewater	1	Higgins
44	Humble	1	Campbell
46	Humble	3	LTC
47	Humble	1	Tucson
49	Tidewater	1	Cato
50	Humble	1	Foremost
52	Tidewater	1	Phifer
53	Sun	1	Camp
54	Tidewater	1	Parker
57	Sun	1	Tillis
58	Sun	1	Roberts
59	Hunt	1	Fee
62	Humble	1	Keene
64	Humble	B1	GCRC
66	Coastal	1	Ragland
67	Humble	1	Henderson
75	Coastal	1	Wright
77	Humble	1	Cone
78	Grace	1	Lumber
81	Hunt	2A	Peavy
89	Sun	1	Williams
90	McCord	1	Starling
91	Hunt	3	CNS
93	Sun	1	Sapp
96	Sun	1	Westbury
97	Sun	1	Crapps
100	Coastal	1	Sapp
101	Sun	1	Parker
104	Sun	1	Johnson
105	Humble	1	Robinson
107	Sun	1	Lloyd
108	Coastal	1	State
109	Sun	1	Russell
111	Sun	1	Bishop
114	Gulf	1	Scanlon (Blk 49)
115	Coastal	1	State (340)
116	Gulf	1	Scanlon (Blk 42)
119	Gulf	1	Scanlon (33)
120	Gulf	1	Scanlon (37)
121	Humble	16	GCRC
124	Gulf	1	Vining
126	Natl Turp	1	Fee
130	Humble	1	Collier
133	Humble	B1	Collier
143	Humble	1	Taylor
148	Sinclair	1	Williams
152	Coastal	1	Tiedtka
160	Gulf	1	CNS
161	Humble	1	Kirchoff
162	Commonwealth	1	Red Cattle
167	Commonwealth	1	Wisehart
178	Gulf	1	Vanderbilt
182	Gule	1	State
207	Humble	1	CNS
222	Humble	1	Curry
225	Conoco	1	Carlton
230	Warren	1	Terry
232	Gulf	1	State 826-C
235	Amerada	1	Southern States
236	Magnolia	1	Schroeder
237	Amerada	1	Swenson
238	Texaco	1	Creighton
243	Amerada	1	Mitchell
259	Amerada	2	Cowles
265	Humble	1	State 2004
269	Amerada	1	Lykes
271	Humble	1	CNS
275	Gulf	1	State 826-Y
284	Gulf-Calco	1	Block 28

Permit	Operator	Lease	
289	Calco	1	State 224-B
290	Gulf-Calco	1	Block 44
291	Humble	2	Miles Collier
295	Gulf-Calco	1	Block 46
298	Calco	3	State 1011
304	Calco	3	State 224-B
306	Dupont	1	Fee
309	Mattaliano	2-A	Buckeye
310	Gulf	1	Stevens
338	Thayer-Davis	1	Ripley
347	Jett	1	Buckeye
350	Mobil	1	Garby
353	Mobil	1	Harband
358	Mobil	1	Camp
359	Sun	1	Con Fin
362	Triangle	1	Lawless
364	Sun	1	Harris
372	Sun	12-2B	Alico
375	Mobil	1	State 224-B
380	Humble	1	Price
382	Mobil	1	State 224-A
383	Mobil	1B	State 224-A
393	Sun	5-2	Alico
402	Dunham	1	Monticello
403	Sun	1	Shepard
404	Durham	1	Gilman
410	Durham	B-1	Gilman
424	Exchange	1	FL Land
449	Pan Am	2	Rayonier
454	Sun	24-1	Collier
459	Exchange	1	Payson
465	Inexco	1	Gilman
472	Exchange	1	Babcock
475	Exchange	1	State 2448
517	Tribal	23-2	Collier
520	Hughes	1	Hunter
532	Humble	20-2	Con Fin
536	Chevron	1	Container
539	Arco	1	Bronson
543	Arco	2	Bronson
544	Humble	304	Leigh Acres
561	Humble	6-3	Oleum
562	Humble	31-3	Collier
564	Reynolds	1	Axelson
574	Hamilton	1	Keen
597	Kaiser	3-1	Injection
606	LL&E	16-4	Barron
608	Arco	16-4	Starkey
609	Shell	1	Punta Gorda
613	Sun	11-2	Turner
626	Sun	31-2	Lee Land
629	Amoco	1	Arnold
649	Getty	20-8	Dicks
650	Getty	4-1	Beillings
653	Getty	21-8	Holmes
666	Getty	33-16	Marsh
679	Amoco	19-2	Knight
683	Kirby	1	State 1307
699	Tribal	18-4	Collier
700	Tribal	7-2	Collier
710	Shell	35-1	Sloan
723	Hunt	1	Hurst
724	Hunt	1	Holmes
725	Hunt	1	Crapps
737	Shell	9-3	Davis
736	Tribal	17-1	Collier
740	Shell	7-4	Gulf & Western
742	Amoco	353	Cummer
743	Amoco	8-4	Larkin
747	Exxon	4-4	Lehigh
759	Amoco	35-4	St. Pete
766	Wainoco	35-2	Collier
772	Amoco	26-1	Peacock
775	Tribal	26-4	Collier
778	Bass	12-2	Pumpkin
781	Kansha	18-3	Seminole
783	Strata	21-4	Collier
785	Amoco	1	USA
795	Amoco	1-A	USA
802	Bass	5-2	Oleum
848	Ashland	32-1	Alico
851	Total	35-1	FL Farms

Permit	Operator	Lease	
854	H&H	21-2	Masterpiece
862	Amoco	6-2	Jackson
864	Coquina	19-3	Collier
865	D.Shamrock	31-3	Gerry
903	HOM	26-3	Seminole
951	Ashland	29-2	Duda
972	Hughes	1	State 803
1015	Amoco	34-15	Exum
1050	NRM	35-4	Alico
1063	Hughes	3-6	Oleum
1193	Hubner	26-2	Lykes
A	Hunt	2	Gibson
B	St Marys	1	Hilliard
C	USGS		D-235
D	Sand Lake	1	Injection
E	Hunt	1	Gibson
F	Hunt	4	Gibson
G	Hunt	3	Gibson
H	Peninsula	1	Cory
J	Republic	1	Robinson
K	Humble	1	IFF

Georgia

GGS	Operator	Lease	
150	Hunt	3	Superior
153	Calco	1	Buie
166	Hunt	1	Superior
169	Hunt	2	Superior
338	Grace	1	Griffis
362	LaRue	1	Massey
724	Humble	1	Union
1198	Pan American	1-B	Union
3537	Amoco	1	Union

Injection Wells

Well	Number	Site
a	5	MDWS
b	2	Pembroke Pines
c	3	Ft. Lauderdale
d	1	Plantation
e	1	Coral Springs
f	2	Broward North
g	1	PB System 9
h	1	PB System 3
i	1	Acme
j	1	Belle Glade
k	4	Quaker Oats
m	1	Pahokee
n	1	Pratt & Whitney
p	5	West Palm Beach
q	2	SWA
r	1	Sea Coast
s	1	Encon
t	1	DeBartolo
u	1	North Port
v	1	Ft. Pierce
w	1	Hercules
x	2	Harris
y	1	D.B. Lee
z	expl	Merritt Island

Appendix 1

GLOSSARY

Euhedral dolomite - rhombic crystals are visible; sucrosic dolomite is always euhedral, but euhedral dolomite need not be sucrosic.

Anhedral dolomite - light reflections indicate a crystalline structure, but rhombic crystals are not visible. In this variety the crystals are interlocking.

Cryptocrystalline - has a smooth appearance with no crystal reflections; in some cases it is lithographic and may have conchoidal fracture, thus resembling chert.

Boulder Zone - a section of any dolomite interval which, either from breaking in the roof of a cavity by the drill bit, or the collapse of highly-fractured dolomite in the wall of the drill hole, deposits large pieces of dolomite in the bottom of the hole. These, when drilled, behave as if they were in-place boulders, hence the name bestowed by the early drillers in Florida.

Suite - a vertical grouping of lithologies distinguished from adjoining vertical groups by a distinctive lithologic assemblage.

Appendix 2

CEDAR KEYS

Considerable confusion is present in even identifying the type well for the Cedar Keys Formation. It was named by Cole (1944, p. 28) probably from a well in Levy County known at the time as "Cedar Keys No. 2", but which is now known as the Florida Oil Dev. No. 2 Scholtz Land. Cole did not specify a depth for either the top or the base of the unit in this well, and in his paper he only mentions a depth from the St. Mary's River 1 Hillard well across the state in Nassau County. Although there is some contention that the Hillard well is the type locality, Cole's selection of "Cedar Keys" as the name for the formation strongly points to the "Cedar Keys No. 2" well as the type locality. No one in the ensuing 32 years has seen fit to formally designate a type well or interval for the Cedar Keys, so I herein formally propose the Florida Oil Development No. 2 Scholtz Land well drilled in 1939 in Sec 9-T15S-R13E, Levy County as the type well. It is catalogued in the Florida Bureau of Geology files as W-355 (no permit). The type interval is designated at 1856 ft to 2490 ft.

Original Type Well Description

None was presented by Cole (1944). The Cedar Keys in his definition ". . . is designated to cover . . . (the interval from the first appearance of the *Borelis* fauna to the top of the Upper Cretaceous" (depth or criteria unspecified).

Applin and Applin (1944) presented a description of the No. 2 Scholtz well on their graphic log illustration (p. 1752 and it is here presented . . . . . as a substitute for the non-existent original description. (Winston 1977)

In the adjacent Section 16, Coastal drilled the No. 2 Ragland. As this well has an E-log, it was designated the co-type well (Winston 1977); the lithology is described below.

Co-Type Well: Coastal 1 Ragland, P 66, 16-15S-13E, Levy County

Co-Type Interval: (revised) 1805-2540 feet E-log; 1800-2565 feet samples

Co-Type Description: At the top is 20 feet cryptocrystalline tan dolomite with anhydrite nodules. Beneath is 60 feet of euhedral dolomite, tan and brown, medium crystalline and porous. This section is Rebecca Shoal Tavernier Tongue.

Beneath this section is 685 feet of interbedded euhedral, gray, chalky dolomite and very fine microcrystalline tan dolomite with relic skeletal grains. Anhydrite nodules are prominent in the lower 430 feet, and one anhydrite bed is present.

Basin Reference Well: Amoco 19-2 Knight, P 679, 19-36S-27E, DeSoto County

Reference Interval: 2880-5375 feet E-log; 2880-5400 feet samples

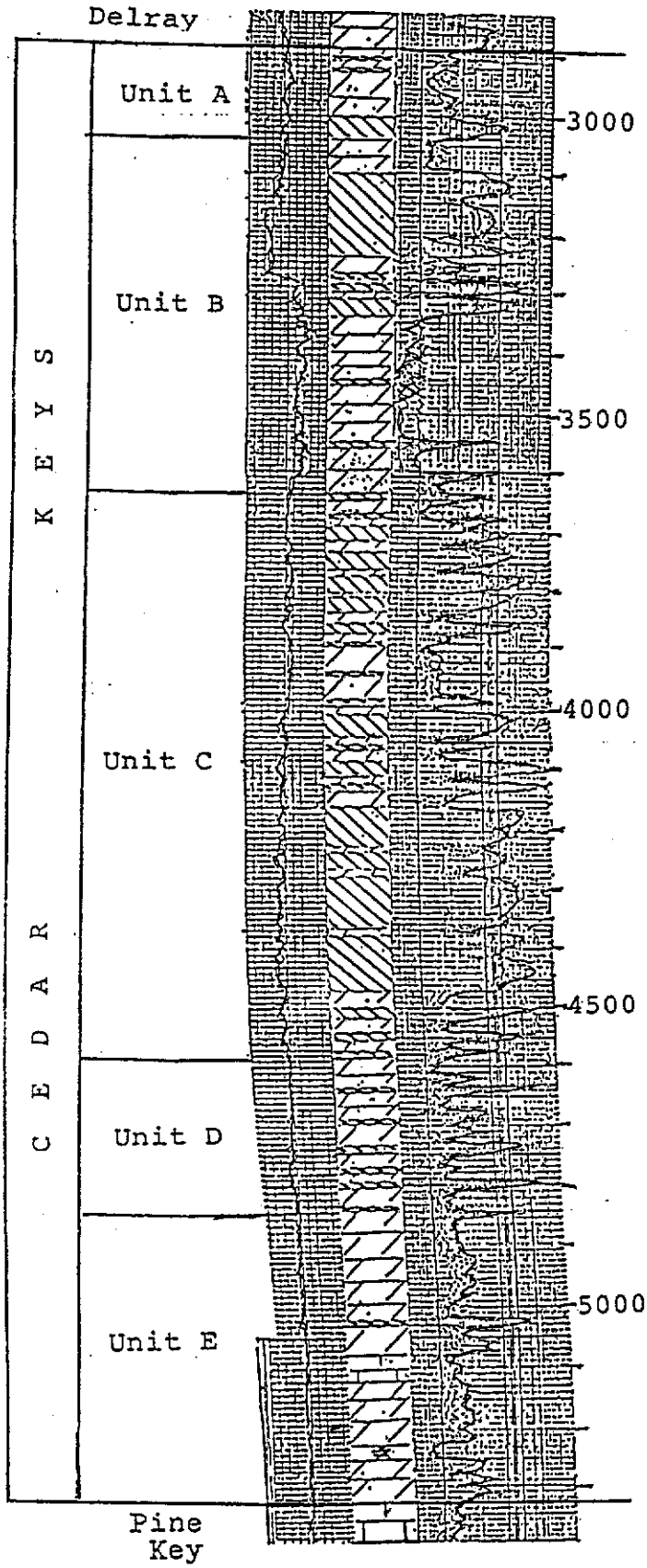
Reference Description: The Cedar Keys is subdivided (Winston 1994) into six units. Unit A consists of 170 feet of gray and tan, cryptocrystalline and microcrystalline euhedral dolomite with relic skeletal texture and bedded anhydrite. Unit B consists of 590 feet of gray and cream microcrystalline euhedral dolomite and anhydrite. Unit C consists of 925 feet of anhydrite with interbedded dolomite, tan, cream and gray euhedral microcrystalline to chalky with occasional relic skeletal texture. Unit D consists of 290 feet of gray and cream microcrystalline euhedral dolomite with interbeds of anhydrite. Unit E consists of 250 feet of cream and gray euhedral microcrystalline to chalky dolomite with one thin anhydrite. The underlying 250 feet represents an interfingering of Cedar Keys and Pine Key lithologies. The

P 679

BASIN REFERENCE WELL

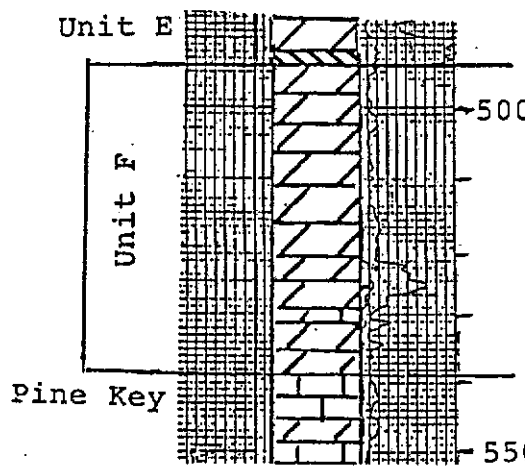
&

TYPE WELL FOR
SUBDIVISIONS A-E



P 167

TYPE WELL FOR
CEDAR KEYS UNIT F



basal unit has a 40-foot bed of skeletal limestone and another of white chalk.

Unit F is not present in the reference well. Well 167DAD is designated the type for the Unit F. It consists of 560 feet of anhedral, cryptocrystalline and microcrystalline euhedral dolomite. Relic pellet and oolite texture is common in the upper 300 feet. Interfingering with the Pine Key Formation is common in this unit.

Comments: Few oil tests penetrating the Cedar Keys recover samples from the top. Circulation is usually lost in the overlying Black Point Format rocks, and casing is not set until several hundred feet into the Cedar Keys, from which point samples are again recovered. P 679 was selected as the Basin Reference Well because it had samples across the boundary, and was in the thicker portion of the anhydrite development.

Thickness Range: 485-2470 feet

Age: Paleocene and Late Cretaceous by paleontology (Cole 1944), Applin and Applin 1944, and Vernon 1951). Vernon states that ..."the Upper Lawson [now incorporated in the basal Cedar Keys] is a transitional bed including fossils characterizing both Paleocene and Cretaceous."

Fauna: Borelis gunteri and B. floridana in Unit B. See Vernon 1951 and Applin and Applin 1944 for fauna in the now-abandoned Upper Lawson.

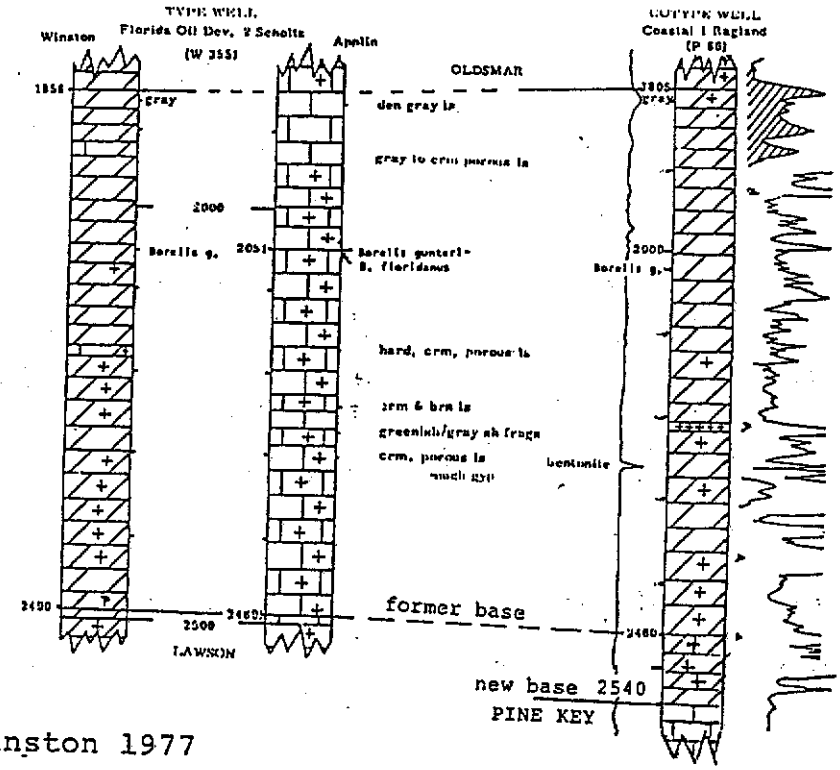
Upper Boundary: (conformable) Defined by the change from brown anhedral or euhedral dolomite of the Black Point Format above to gray cryptocrystalline or anhedral dolomite below. On occasion the gray color of the Cedar Keys is missing and the boundary must be established by the use of geophysical logs.

Lower Boundary: (conformable and interfingering) Defined by the change from tan, cream or brown, euhedral dolomite occasionally with relic oolite or skeletal texture above to cream limestone or white chalk of the Pine Key below.

Correlatives: Tavernier Tongue of the Rebecca Shoal Dolomite, lower MADco Suite (Winston 1993a) and Midway section of the western Panhandle

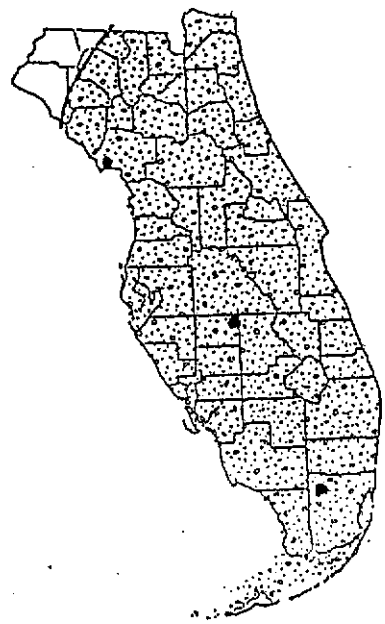
References:
Cole 1942
Cole 1944
Applin and Applin 1944
Vernon 1951
Chen 1964
Winston 1977
Winston 1993
Winston 1994

TYPE & REVISED CO-TYPE WELLS



after Winston 1977

DISTRIBUTION OF CEDAR KEYS



Appendix 3

Black Point Format

Type Well: MDWS 5 Injection (W-13768, M57) 21-56S-40E Dade County

Type Interval: Top 1030 feet samples, 1035 feet GR log; base 3160 feet samples, 3165 feet GR log

Name Derivation: from Black Point on Biscayne Bay, one mile east of the type well

Thickness Range: 1170 to 2735 feet

Description of contained lithologies: Highly variable - includes light-colored chalky micrite, dense micrite, skeletal wackestone, packstone and grainstone, orange-brown and tan euhedral, anhedral and occasionally cryptocrystalline dolomite. Euhedral dolomite ranges from very fine microcrystalline to medium crystalline.

Comments: Used to refer to the carbonate interval between the base of the Miocene Hawthorn and the top of the Paleocene Cedar Keys regardless of Suite; includes Suwannee, Ocala, Avon Park, Oldsmar formations and their lateral rock equivalents.

The Black Point Format includes the LAFco, PINco, ORco, ChAco and DAco Suites.

Distribution: Entire Peninsula except for Madison and Taylor Counties.

Upper Boundary: Defined, when not outcropping, by the change from the phosphatic carbonates and clastics of the Miocene Hawthorne above to non-phosphatic carbonates of the Black Point Format below.

Lower Boundary: Defined by the change from orange-brown anhedral dolomite above to gray anhedral or cryptocrystalline lithographic dolomite of the Cedar Keys below. Identifying this boundary is aided by regional correlation using gamma ray logs. In the northeastern Peninsula limestone instead of dolomite overlies the Cedar Keys.

Age: Eocene and Oligocene (may include some Miocene in the Keys).

Reference: Winston 1993

Appendix 4

MADco Suite

Type Well: Hunt 1 Gibson (W-1596, M 2) 6-1S-10E, Madison County (Fig. 5)

Type Interval: 0-2350 feet E-log, 0-2380 feet samples

Name Derivation: from Madison County

Thickness Range: 2380 feet in the northwestern Peninsula, 2850 feet in the offshore Jacksonville Well Cluster (see Fig. 2).

Description of contained lithologies:

The MADco is 80-90% limestone, which consists of wackestones and packstones with very fine to fine skeletal grains in a chalky matrix. Colors are cream, white, tan and light gray. Dolomite crystal inclusions are common.

Dolomite, occasionally calcareous, is euhedral, microcrystalline to occasionally medium crystalline, cream and tan. Occasional relic dolomite skeletal packstones may be present. Dolomite is most prevalent in T-2.

Cherty beds are scattered throughout the section, but are most common in the T-3 (Paleocene) section. In the Jacksonville Well Cluster glauconite is prevalent throughout, but in the northwestern Peninsula only a few glauconite beds are present (usually in T-2 and T-3).

Comments:

The Eocene-Paleocene boundary in this Suite is not identifiable by lithology; only a rough correlation by E-log is possible.

In the northwestern Peninsula, the Suwannee-Ocala interval at the top of the MADco is near the surface. Samples are not usually available here, nor is the interval logged.

In the Jacksonville Well Cluster (M 53 & 54), the Miocene is usually a phosphatic limestone. If present, the underlying Suwannee is not identifiable by lithology. In the nearby offshore JOIDES holes (Charm et al 1969) the Oligocene is described as a thin ooze. Cluster wells to the east (downdip) are more dolomitic than those nearer the Cedar Keys-Rebecca Shoal platform to the west.

Distribution:

The MADco occurs in the eastern third of the Panhandle, and extends into the northwest corner of the Peninsula. It is also present offshore on the East Florida Shelf (Jacksonville Well Cluster). MADco lithology is present offshore on the northern West Florida Shelf (Cross-section C-D) beneath the PINco Suite lithology.

Upper Boundary:

Onshore, when not outcropping, it is defined by the change from Miocene phosphatic dolomites, clays, or other sediments of the Hawthorne to non-phosphatic carbonate. Offshore in the Jacksonville Well Cluster, phosphatic Miocene overlies MADco limestone. On the West Florida Shelf, basal MADco lithology is overlain by Eocene PINco lithology (Cross-section C-D).

Lower Boundary:

Defined by the change from dolomitic, skeletal, cherty packstone above to a white chalk, chalky skeletal wackestone, or micrite containing inoceramos prisms of the Pine Key-Selma below.

Age: Includes Paleocene, Eocene and Oligocene.

Reference: Winston 1993

Appendix 5

DELRAY DOLOMITE

Type Well: Palm Beach Co. System 3 No. 1, 10-46S-42E, Palm Beach County

Type Interval: 2930-3305 feet E-log; 2940-3315 samples

Name Derivation: from the adjacent village of Delray Gardens, one mile northeast

Thickness Range: 50-350 feet

Description of Contained Lithologies: consists of the 3 varieties of dolomite - anhedral, cryptocrystalline and euhedral. Cryptocrystalline dolomite is occasionally lithographic with conchoidal fracture causing it to resemble chert. Euhedral dolomite varies from very fine to coarse crystalline. Colors are usually orange-brown, orange-tan, and occasionally tan. Cryptocrystalline dolomite is usually cream-colored.

Porosity consists of intercrystalline, vug, cavities, and caverns.

Comments: The Delray Dolomite with the underlying Cedar Keys Unit A comprises the "Boulder Zone" in southeastern Florida.

Fauna: none

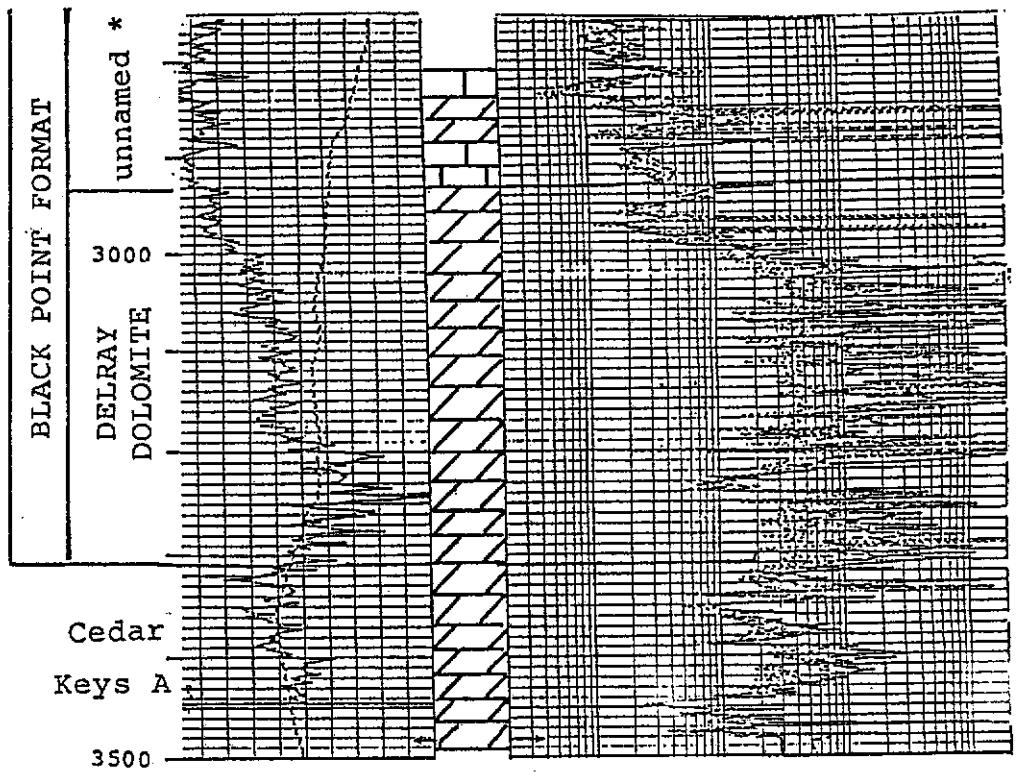
Distribution: The Delray Dolomite is present everywhere in the Peninsula with the exception of the northern tier of counties. It may be absent in the Lower Keys but poor sample quality prevents positive determination.

Age: no data are available. The Delray Dolomite could be of Early Eocene or Late Paleocene age. It is the basal unit of the Black Point Format, considered in the past to be entirely Eocene.

Upper Boundary: (conformable) Overlain in the northwestern Peninsula by limestones of the basal Oldsmar and elsewhere by an equivalent limestone section. In some areas of the southwestern Peninsula, there is a continuous dolomite across the boundary making identification difficult or impossible. This boundary is not a time line, as the Delray Dolomite occasionally extends upward into the overlying limestone by as much as 100 feet.

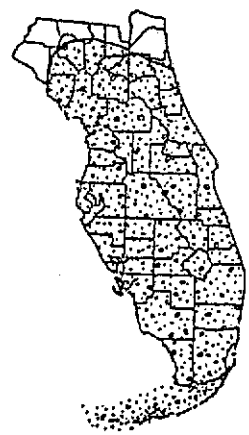
Lower Boundary: (conformable) Defined by the change from brown and tan dolomite of the Delray Dolomite above to gray cryptocrystalline or anhedral dolomite of the Cedar Keys below. On rare occasions the gray color is missing and the top of the Cedar Keys must be picked on geophysical logs.

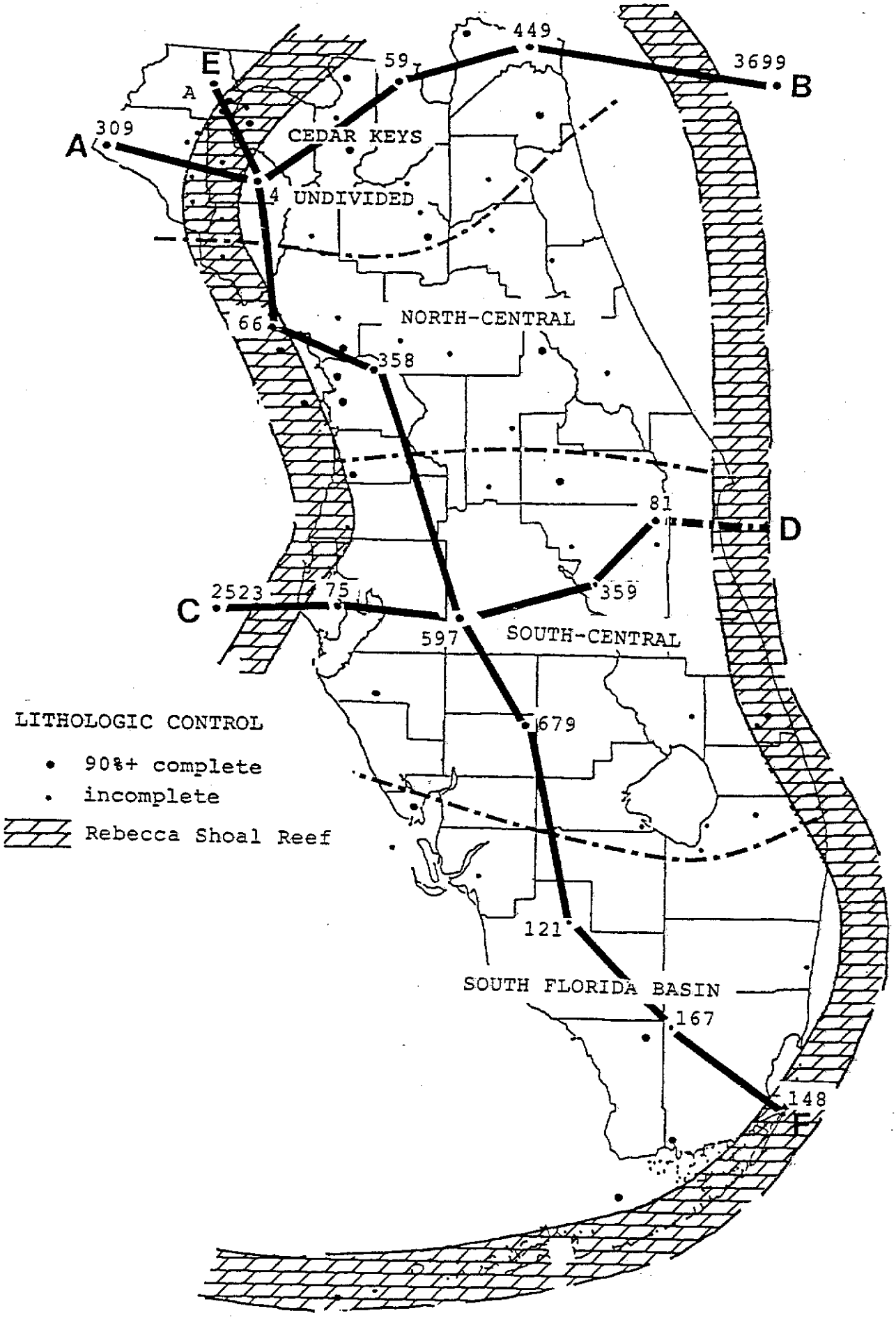
Synomonies: upper part of the Boulder Zone in the southeastern Peninsula



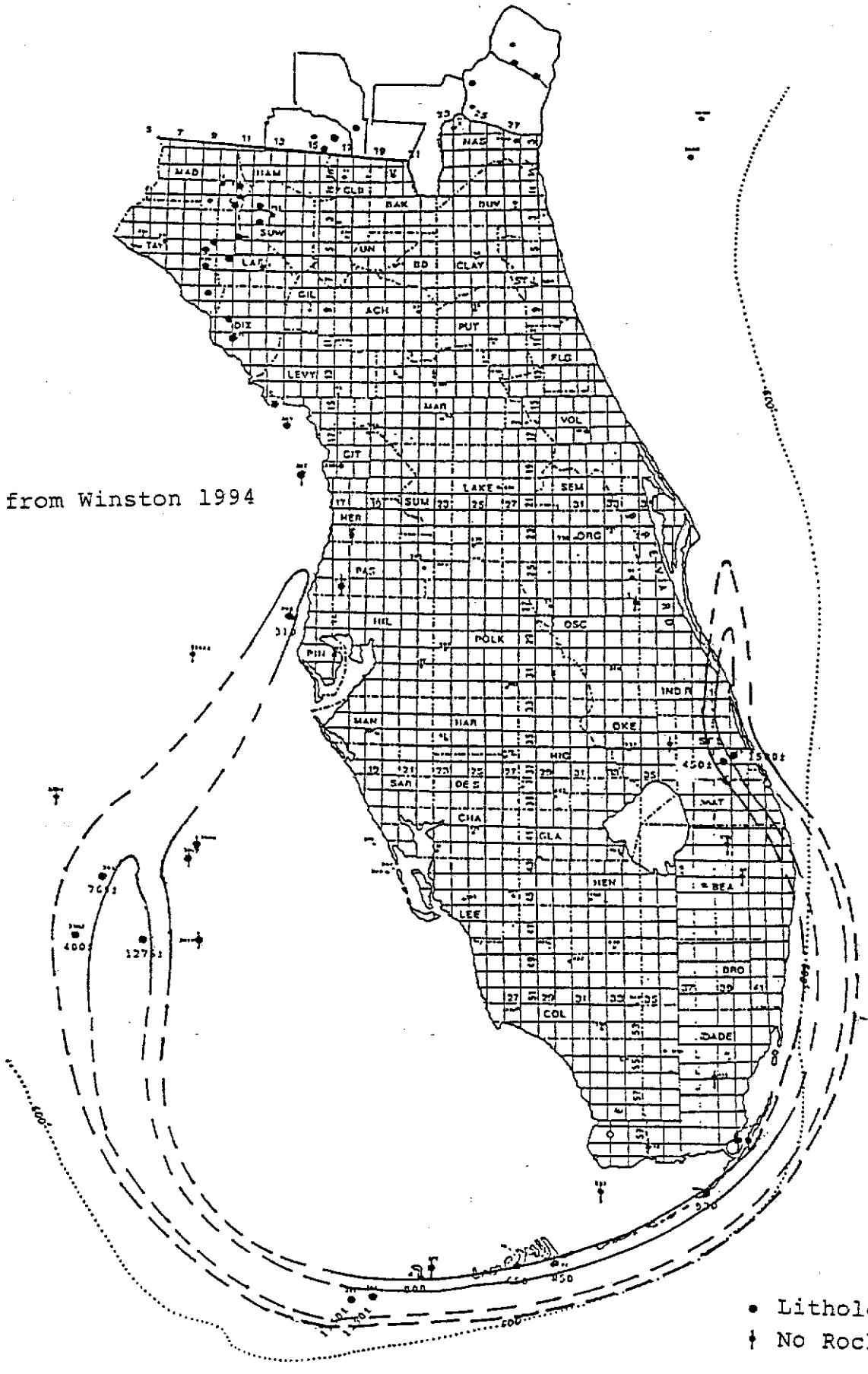
* The Delray Dolomite and the overlying section is the time equivalent of the Oldsmar Formation.

DISTRIBUTION OF DELRAY DOLOMITE



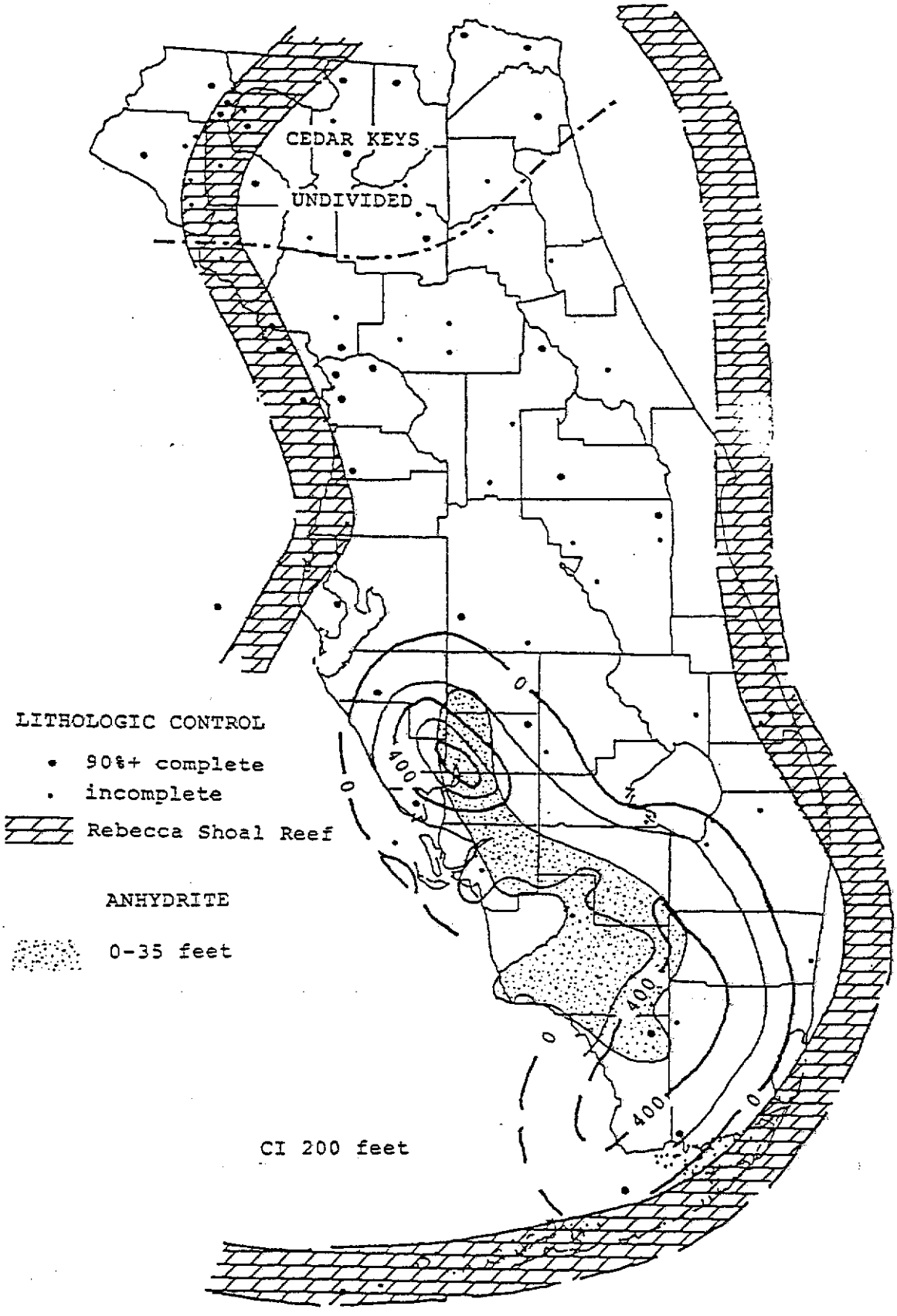


Geographic Subdivisions and Cross-section Index Fig. 1



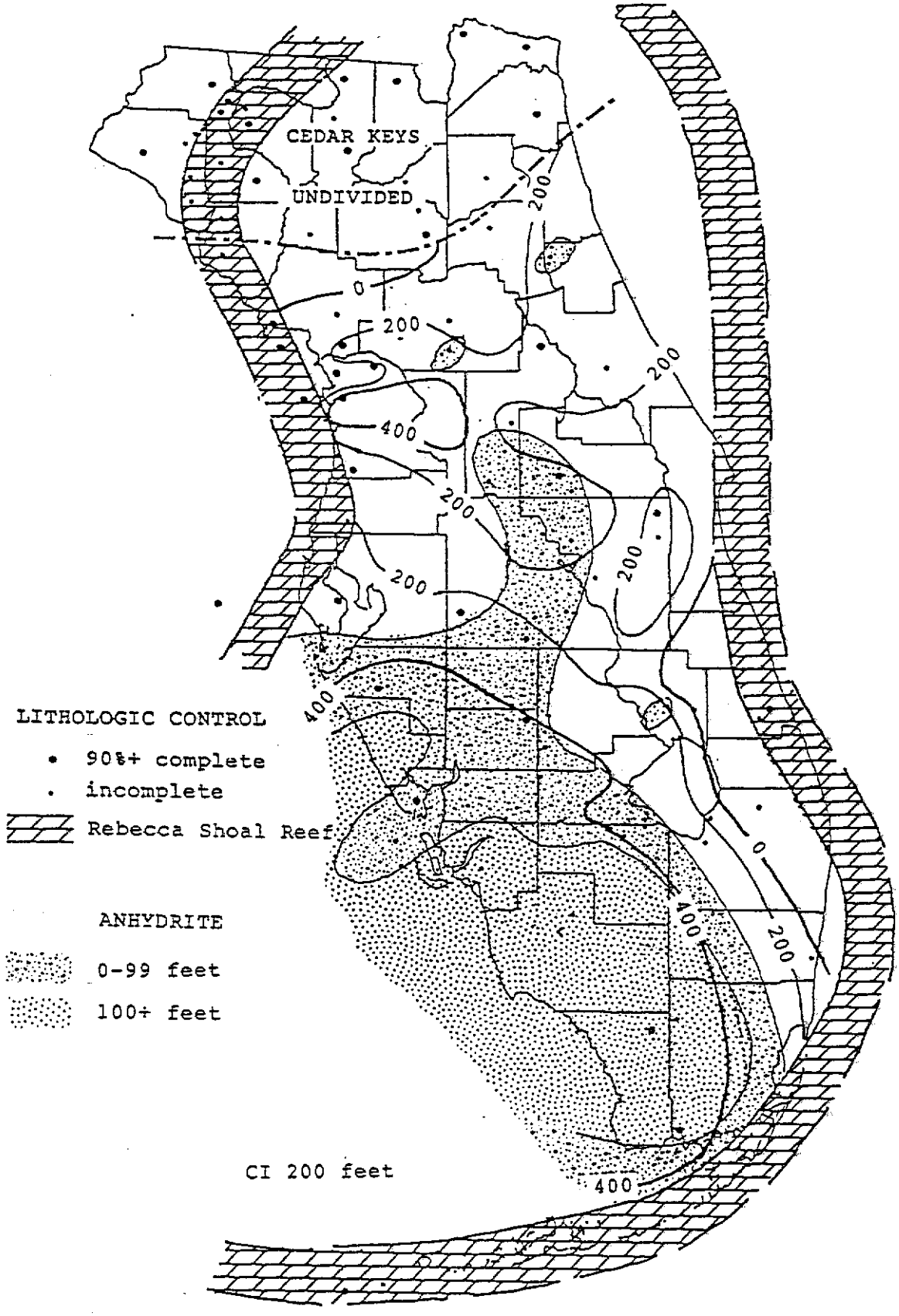
Isopach Plantation Tongue - Rebecca Shoal Dolomite

Fig. 2



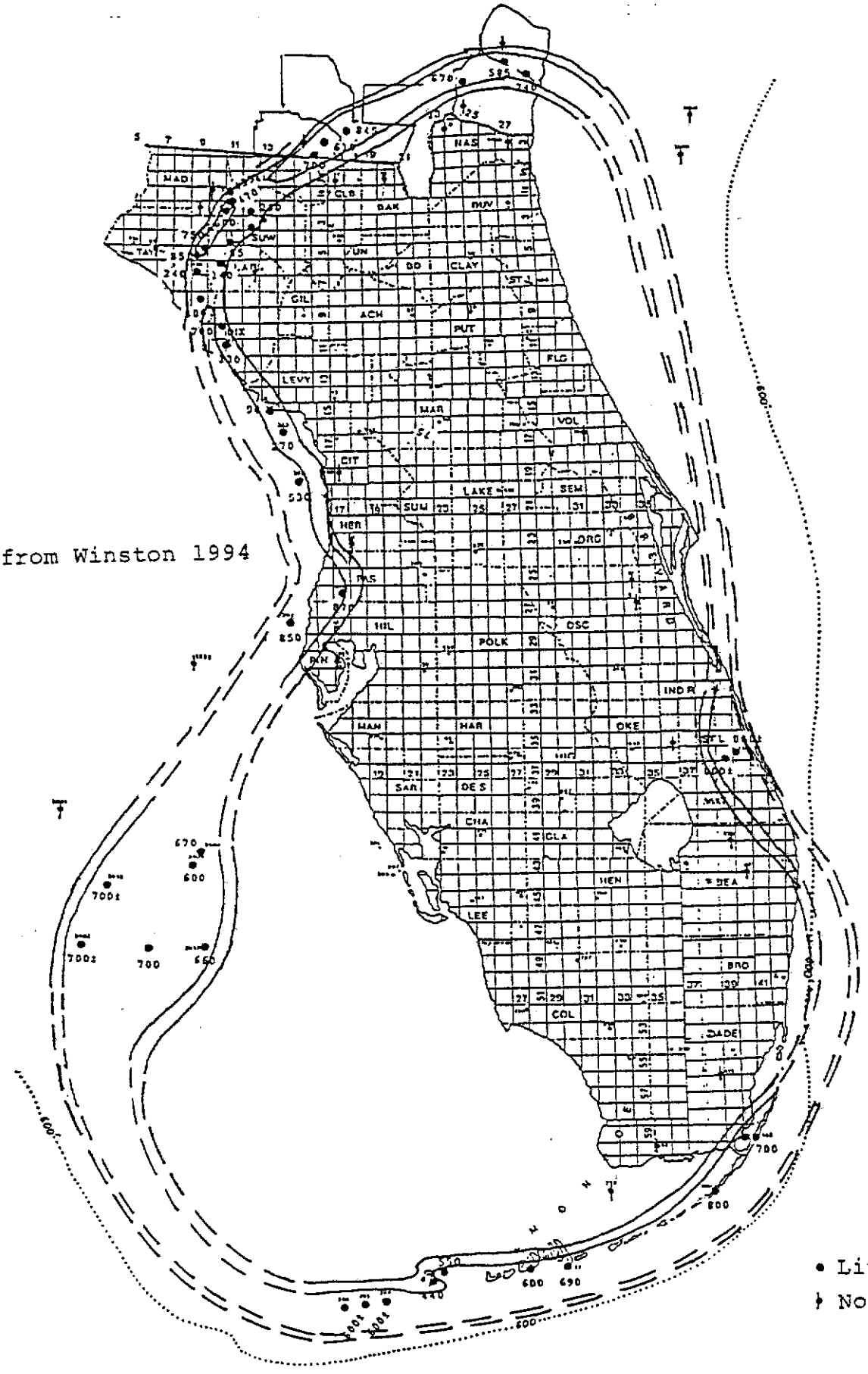
Unit F - Isopach and Anhydrite Isolith

Fig. 3



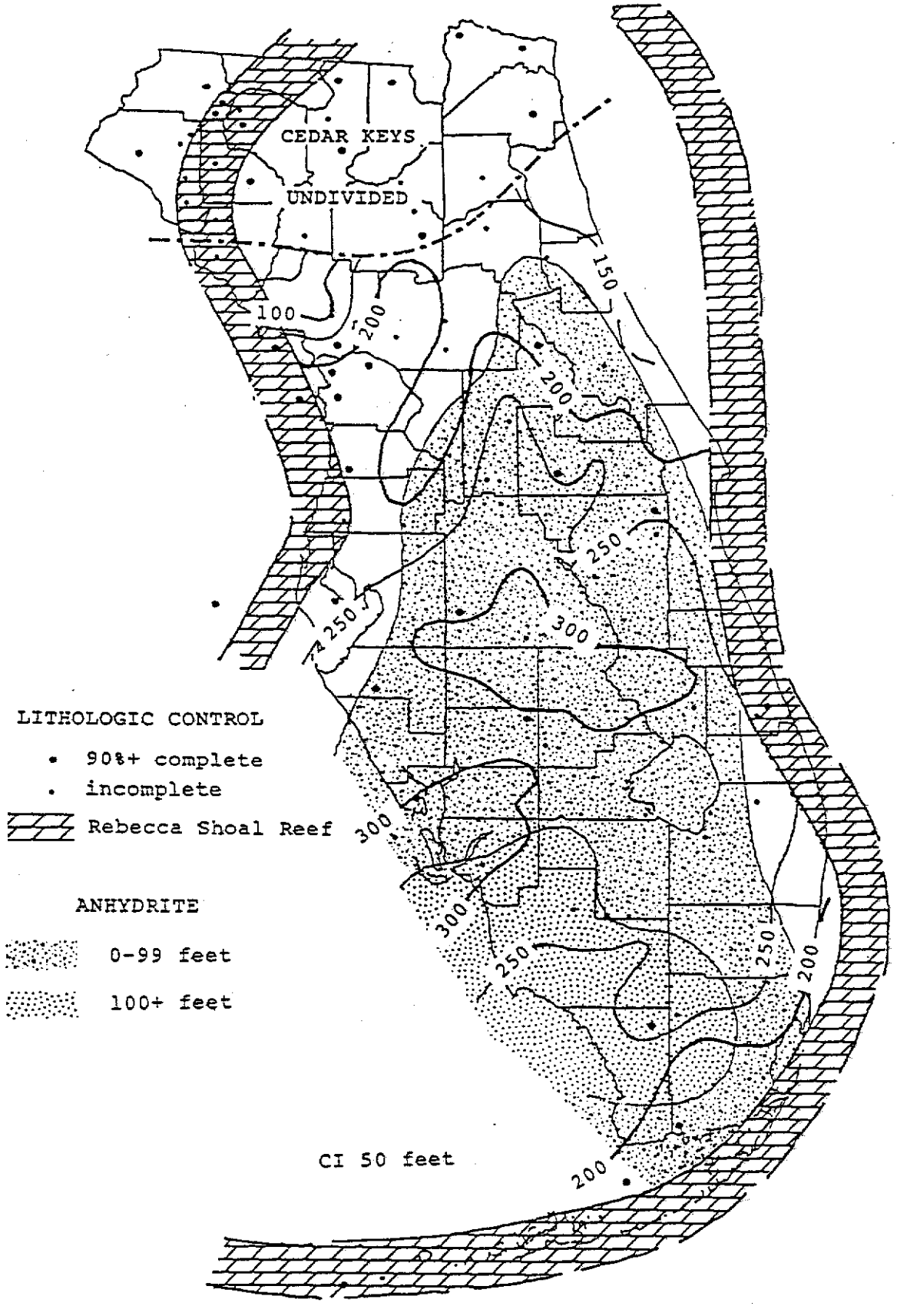
Unit E - Isopach and Anhydrite Isolith

Fig. 4



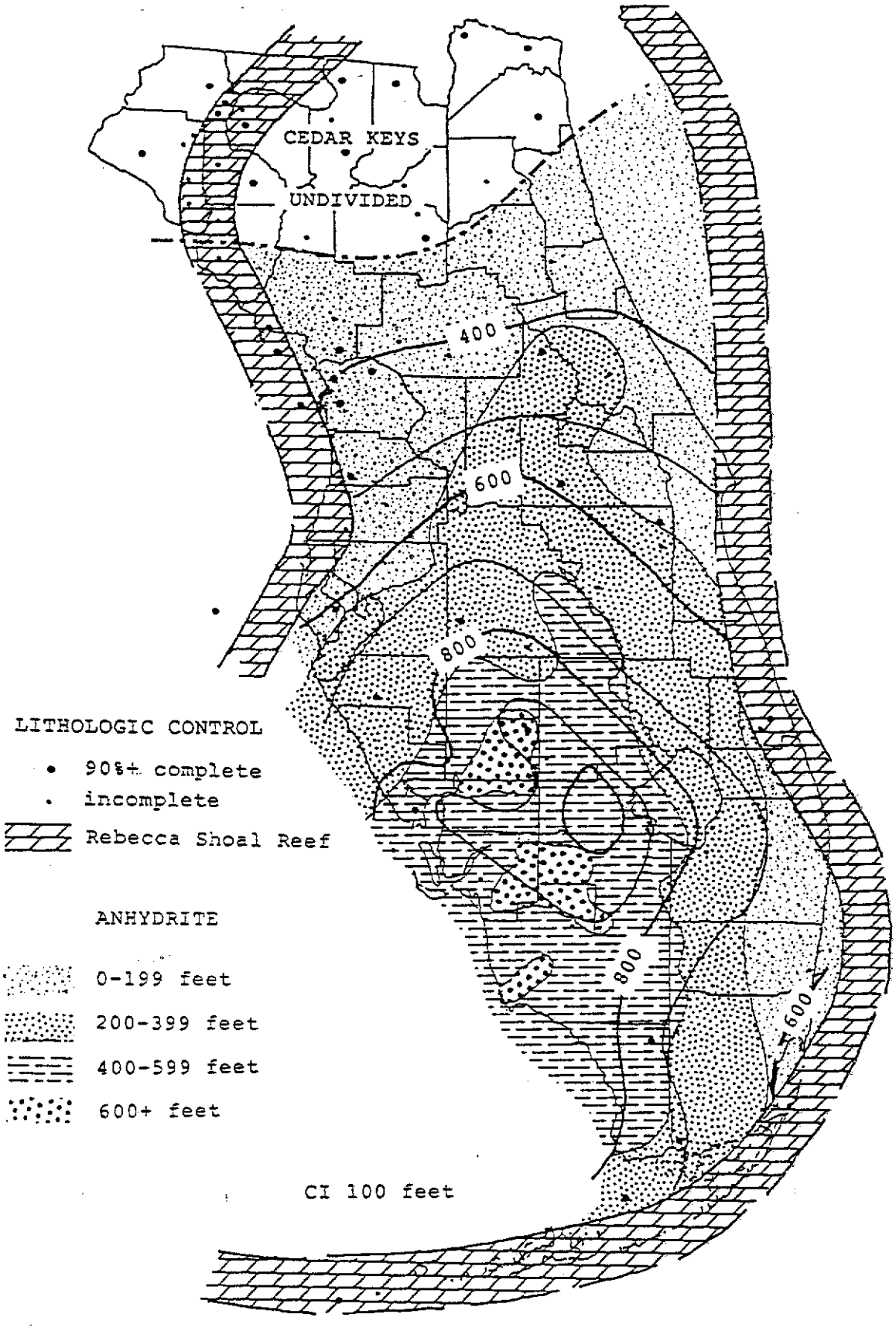
Isopach Tavernier Tongue - Rebecca Shoal Dolomite

Fig. 5



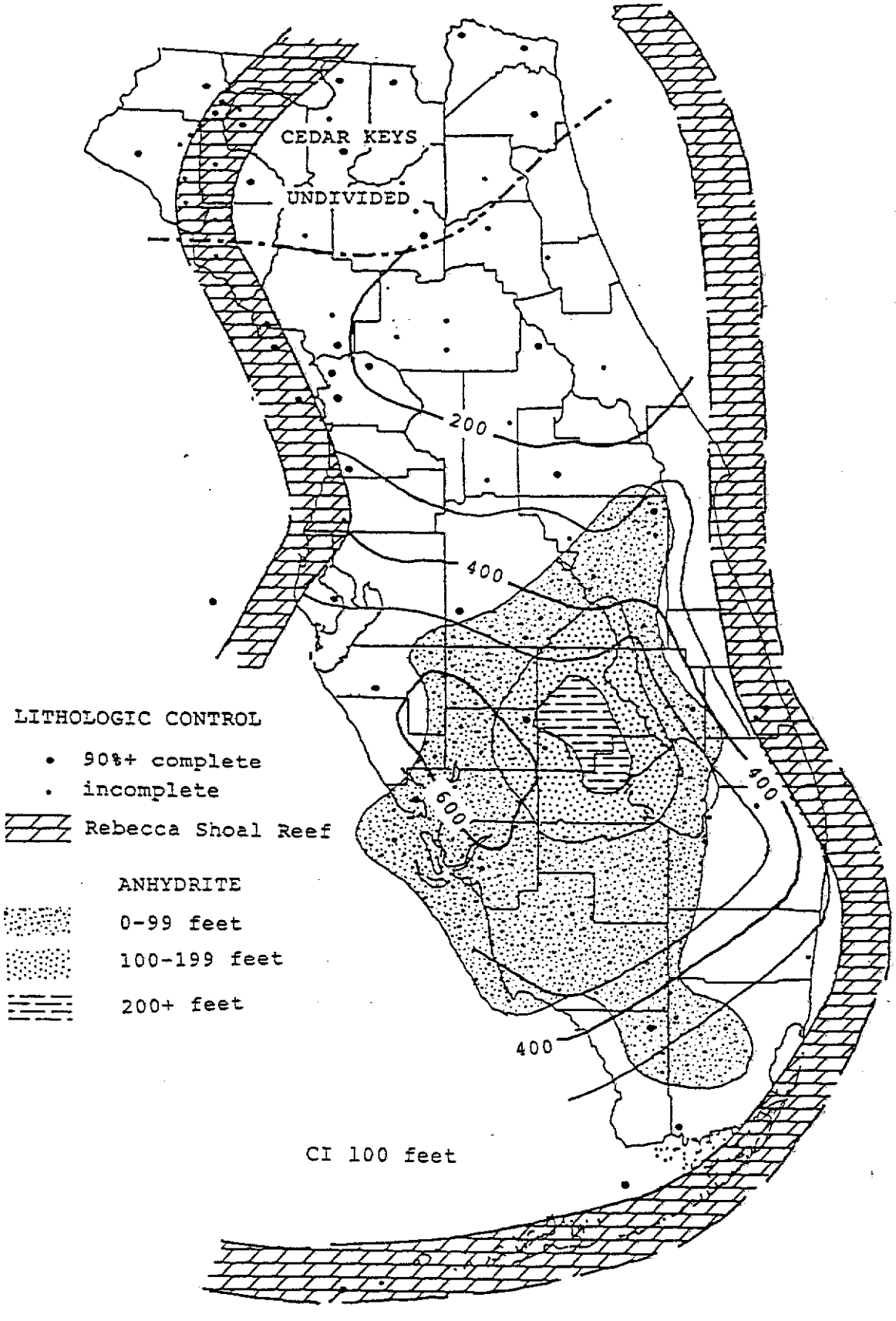
Unit D - Isopach and Anhydrite Isolith

Fig. 6



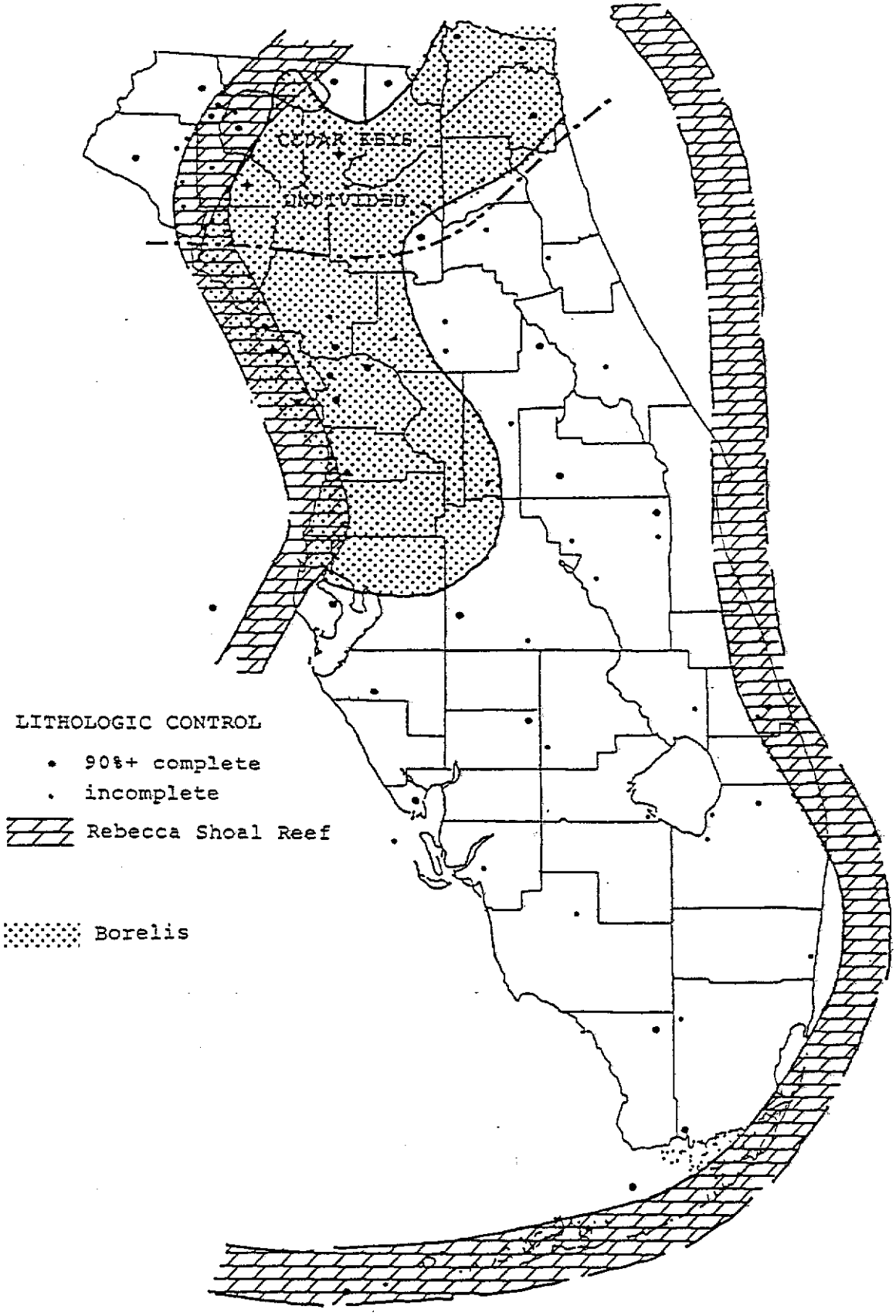
Unit C - Isopach and Anhydrite Isolith

Fig. 7



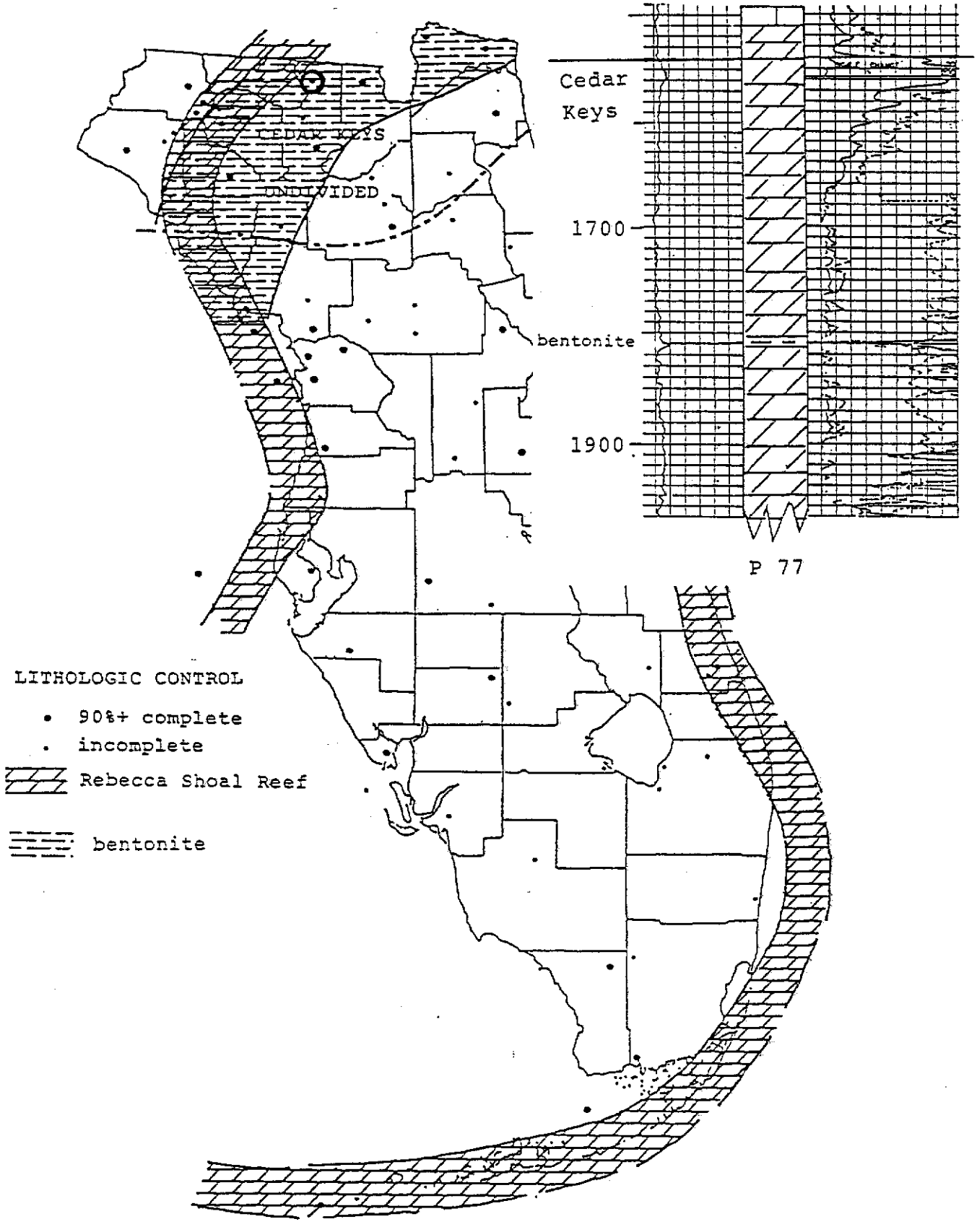
Unit B - Isopach and Anhydrite Isolith

Fig. 8



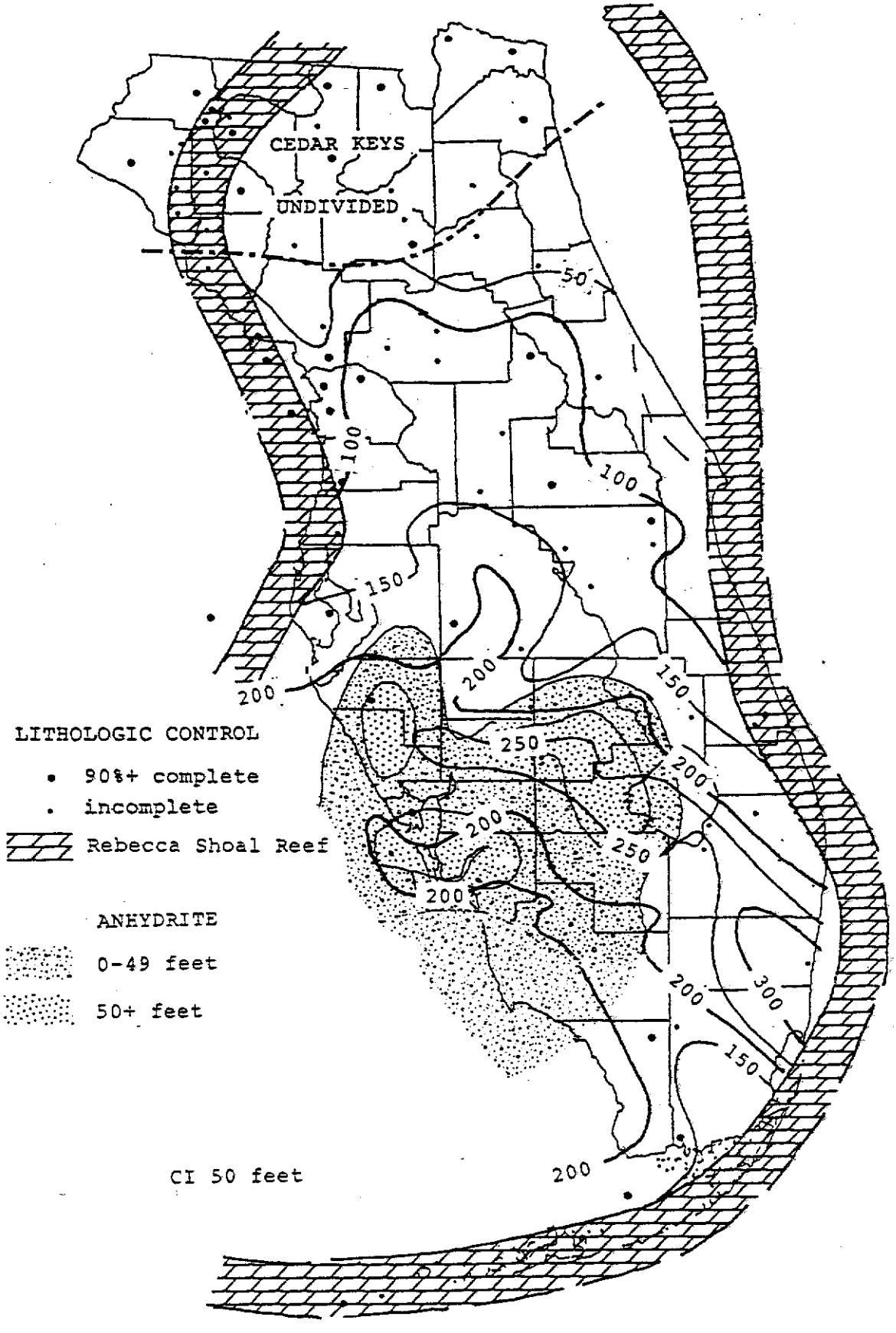
Areal Distribution of Common Borelis Occurance

Fig. 9



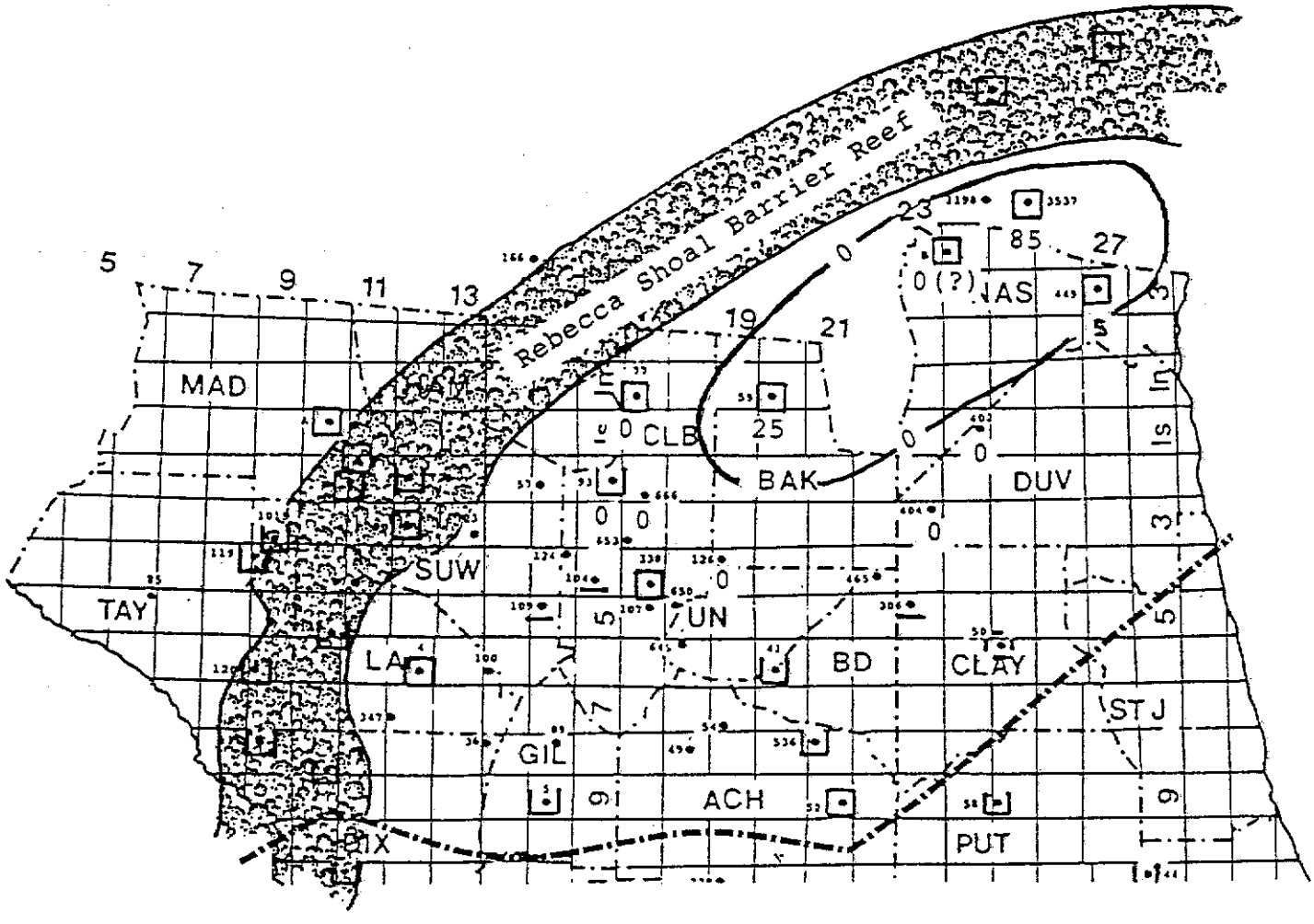
Areal Distribution of Unit B Bentonite

Fig. 10



Unit A - Isopach and Anhydrite Isolith

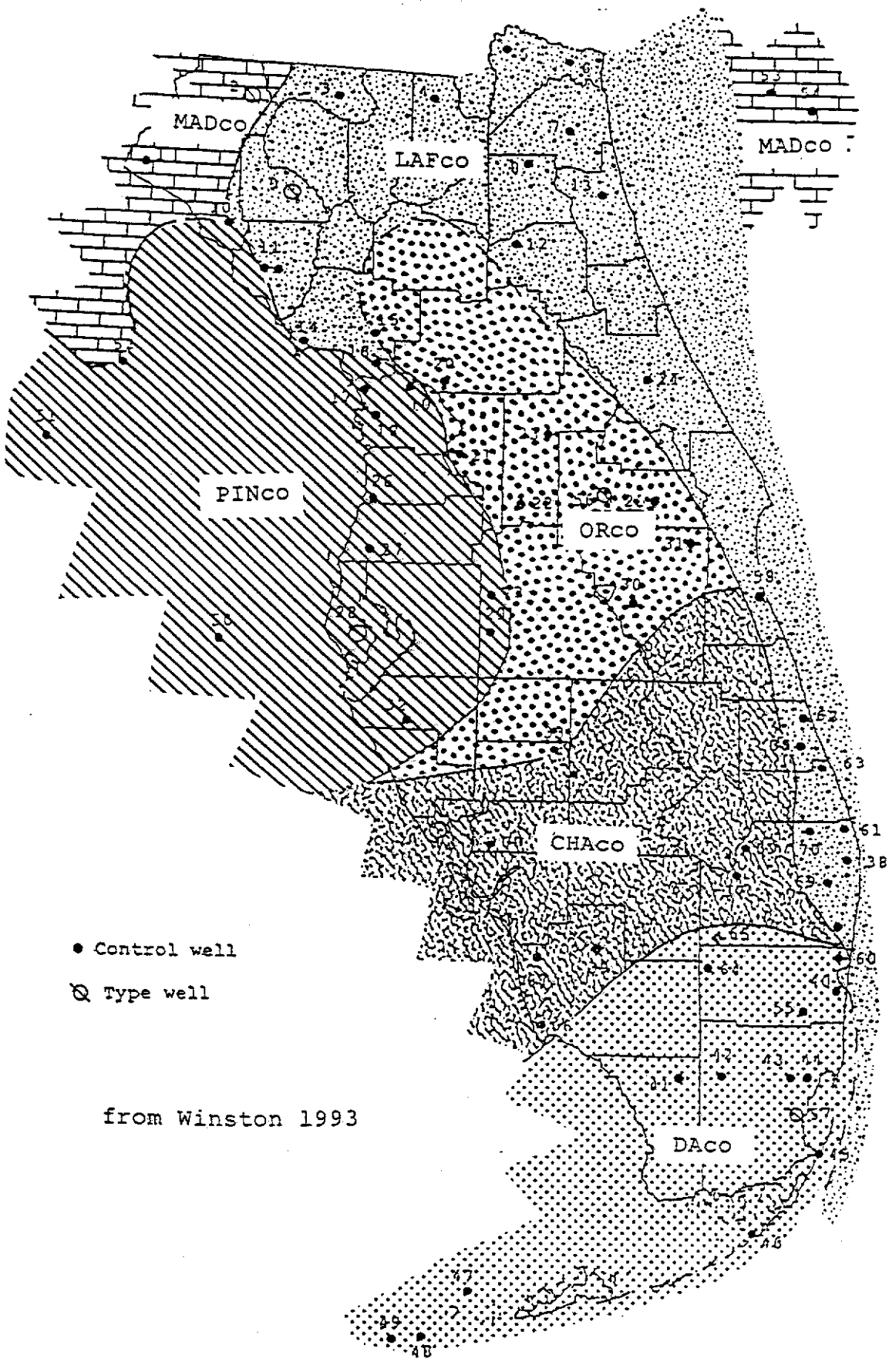
Fig. 11



Distribution of Anhydrite

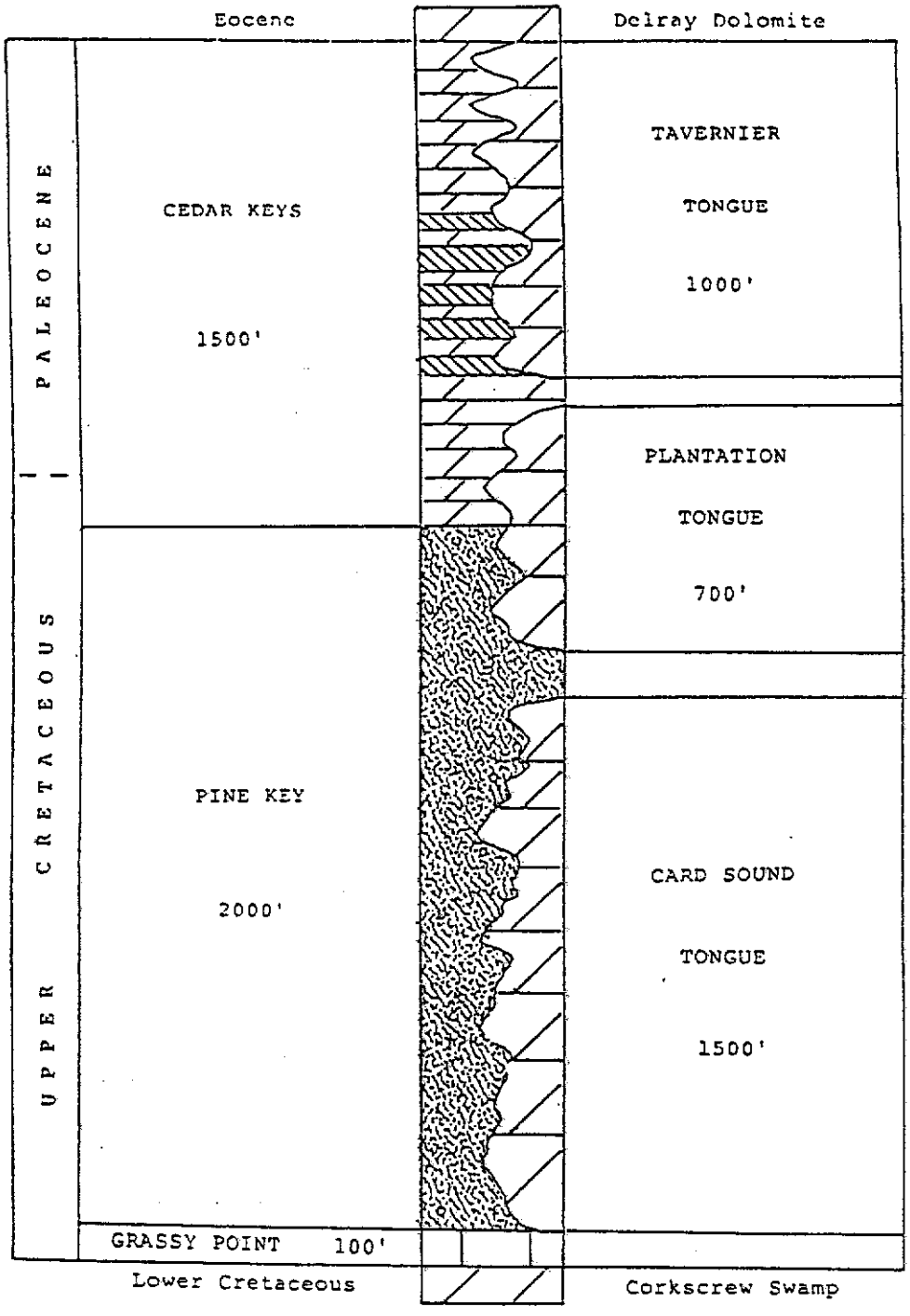
Cedar Keys Undivided

Fig. 12



Areal Distribution of Black Point Suites

Fig. 13



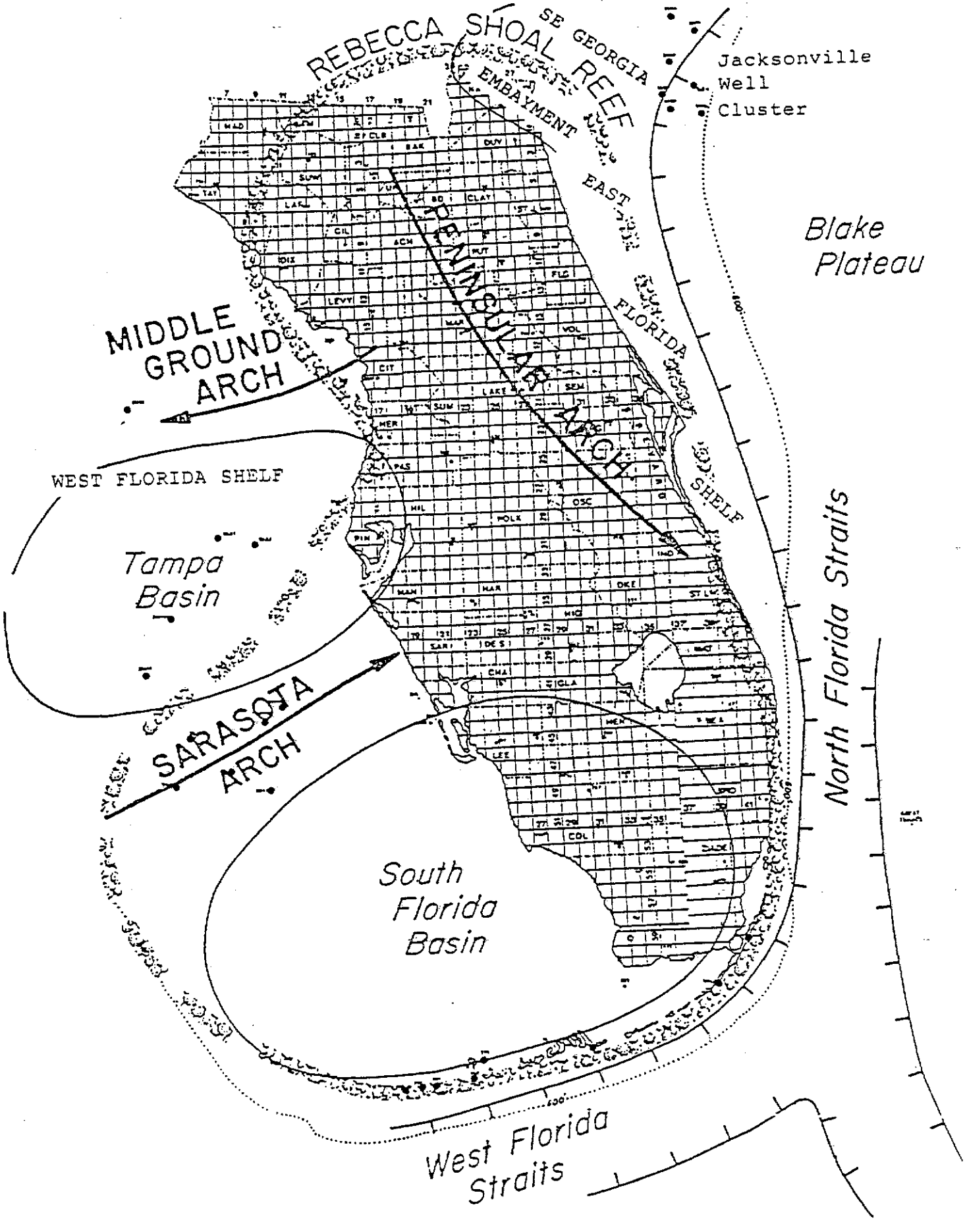
from Winston 1994

limestone
chalk
anhydrite
dolomite
reef dolomite

Generalized Geologic Column

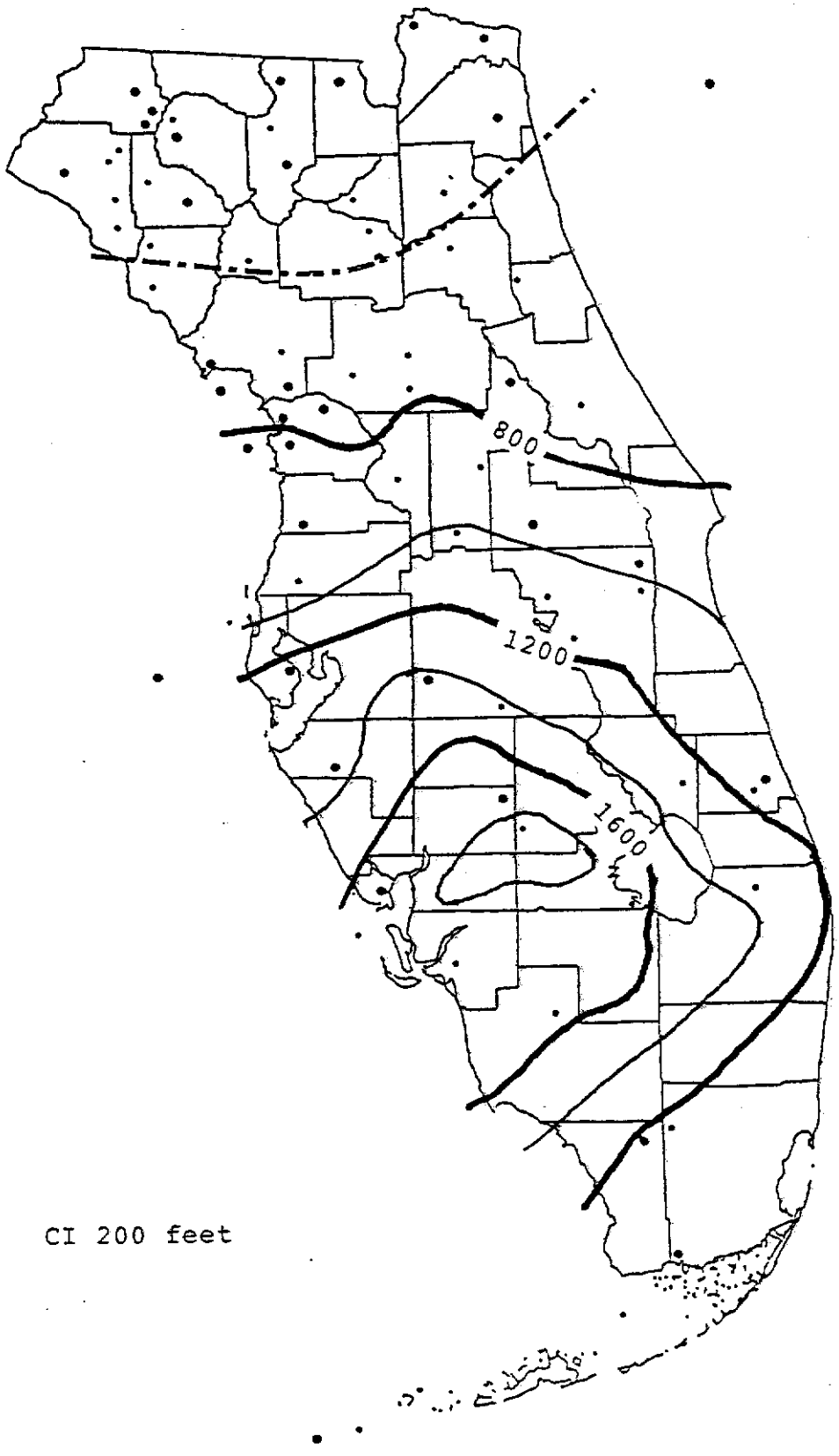
Rebecca Shoal Reef and Lagoonal Facies

Fig. 14



Regional Structure

Fig. 15



CI 200 feet

Implied Cedar Keys Structure
from Isopach of Units A-D

Fig. 16